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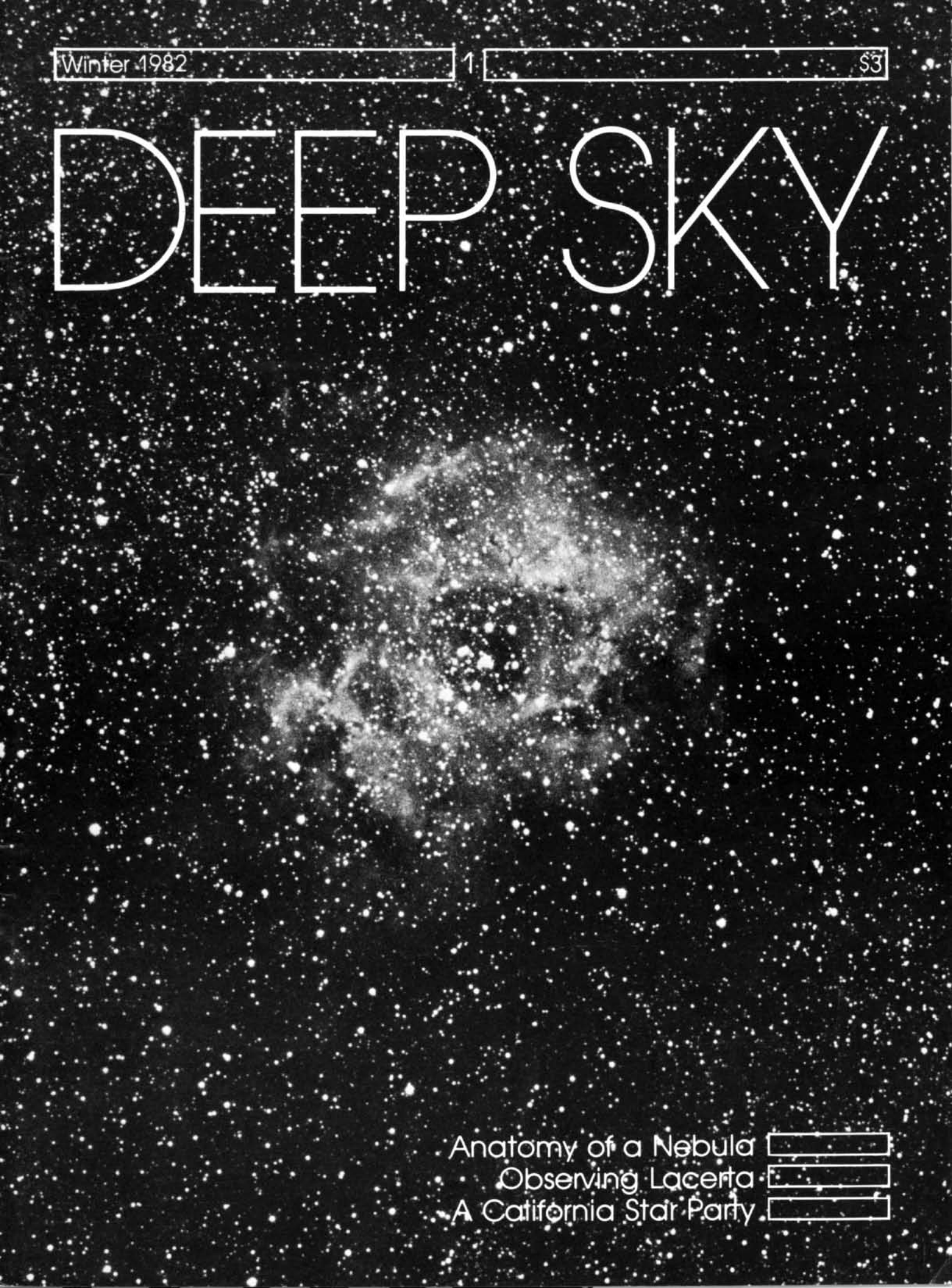
DEEP SKY



Anatomy of a Nebula

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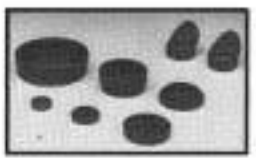

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DEEP SKY

The Magazine for Deep-Sky Observers and Astrophotographers

Winter 1982 Volume 1, Number 1

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Cover: Although difficult to visually observe, the Rosette Nebula in Monoceros is a splendid example of an HII emission region. For an in-depth look at how another Monoceros nebulosity works, see page 6. Photo by Al Lilge, who used a 4-inch f/6 astrograph and a yellow filter, and exposed for 60 minutes on 098-04 emulsion. This page: Seen through large amateur instruments, the Rosette is a large hazy circular object that shows very little detail. Sketch by David J. Eicher.

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Letters to DSM

The new DSM

Dear Dave:

I can't tell you how ecstatic I am over your decision to change DSM. It means the door has opened so you can do what you want to do, the thing you are probably obviously created for. And with the backing of a major magazine you will surely do well. I won't wish you good luck — you really will have no need for that.

Walter Scott Houston
Boardman Road
East Haddam, CT 06423

Thanks, Scotty!

Dear David:

I was pleased to find the February and March DSMs in my mailbox yesterday — glad to see you're still at it! I think you put out a fine magazine considering the small number of contributing writers you have (I will start contributing if our club ever gets our *°#%&* 19" reflector back in operation again!). But for what my advice is worth, don't burn yourself out. Do yourself a big favor and rename your magazine "DSQ" (Deep Sky Quarterly). Consolidate your multi-part articles into full-length features, put the magazine out every three months, and restore your on-time delivery without going crazy! I doubt that any readers would object.

George D. Ellis
7117 Misty Meadow Drive South
Fort Worth, TX 76133

George / Thank you for the comments and suggestion. It was, indeed, a timely one.

Dear Sir:

I have really enjoyed your publication more than the other two major magazines on the market today ("Sky and Telescope" and "Astronomy"). I've subscribed to many different publications over the years, finding some bad and some good. Your magazine is the one I've been hunting for 25 years. I've known about you before, but after subscribing to many and finding out that they were not what I wanted, I became a little "gun-shy." Your magazine is different; I have read and re-read every issue of DSM that I have received. I've gleaned many ideas from DSM over the past year as I like to observe with no great interest in research. I rely on DSM to tell me how to do this better and to tell me what I'm looking at. Your magazine has greatly increased my enjoyment of the hobby.

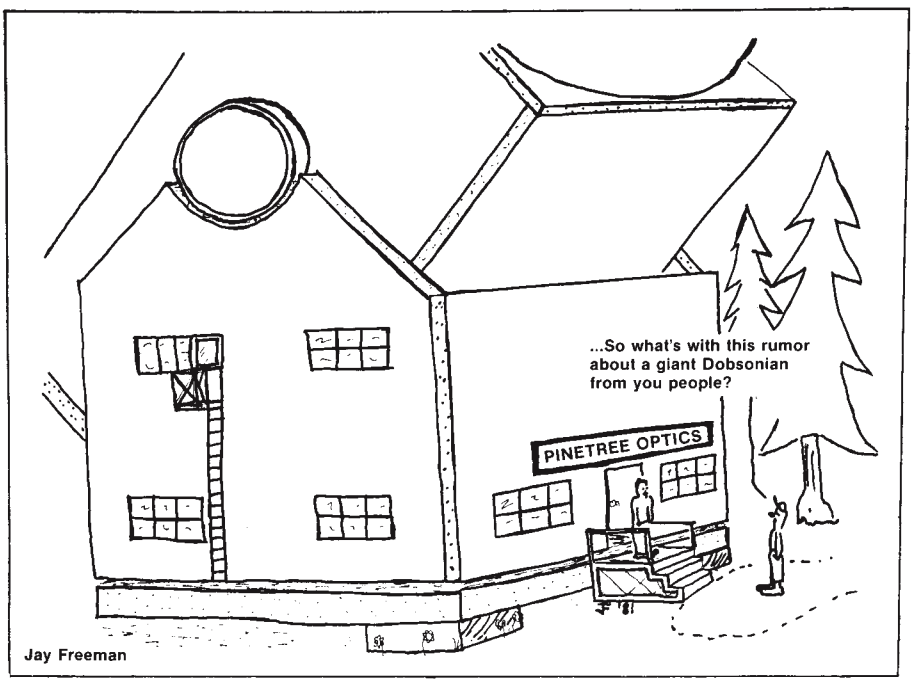
You and your magazine are to be commended for the pleasure you have brought to observers like me who like to look and know what we are looking at.

William H. Rowland, Jr.
AIMD/GSE
N.A.S.
Norfolk, VA 23511

Globulars in M31

Dear Sir:

In the March 1981 issue of DSM there was an article on globular clusters in the Andromeda Galaxy. Unfortunately, the area shown does not include the very brightest of them. This cluster and a few others are, however, shown on a photograph on page 490 of the November 1979 "Sky and Telescope." The cluster is number 12 in the Hubble-Baade Catalogue. My observations made with a 6-inch f/8 reflector give it a brightness of



about magnitude 13.5; it was extremely faint, but I am sure that I detected it. In the December 1981 issue of "Sky and Telescope," you can read about more observations of globulars in M31 made with small instruments. The cluster 254, which is probably beyond the reach of my telescope, is shown but not indicated on page 8 of the March 1981 DSM.

I think it would be a good thing to mention that there are some brighter clusters in a future issue of DSM.

When I observed "12," I also tried to find the starcloud, NGC 206. I succeeded but it was extremely faint.

Ulf Danielsson
Box 8055
77100 Ludvika
SWEDEN

"Faint Fuzzy" Near the Owl

Dear Dave:

Regarding your discussion in DSM about the faint fuzzy object just 3.6' southeast of the nucleus of M97, I have substantive news. The object (which appeared on the May 1981 DSM cover and in the letters section of the November 1981 issue) is known as Keeler 330, taken from a list of 744 faint nebulae discovered at the turn of the century by James Keeler, who used the 36-inch Crossley reflector at Lick Observatory, Mount Hamilton, California. It is listed in the "Publications of the Lick Observatory," Volume VIII, 1908, in an article by Keeler.

The epoch 1950 coordinates for this object are: 11h12m05s, +55°13.59', according to the "Master List of Nonstellar Optical Astronomical Objects" by Dixon and Sonneborn. The MOL gives no description, but Keeler's original code reads B, irr, B*n (bright, irregular, bright star to the north). This description seems to agree with the object in question. I believe the attached star's photographic magnitude is about 14 or 15. The object is also listed in B. Vorontsov-Velyaminov's "Morphological Catalogue of Galaxies," Volume 1, 1962, Moscow. It is listed as MCG +09-19-014, with a photographic magnitude of 17. It is classified by Vorontsov-Velyaminov as L; 22cm (lens shaped, brightening toward the center, two long opposing spiral arms, with the outer arms just starting to show some resolution). The MCG gives the diameter as 24" x 18". My own calculations, based on Perek and Kohoutek's "Catalogue of Galactic Planetary Nebulae" (1967), show it to be 9.7" x 16.5" in extent.

This object is obviously intriguing. I don't really think it's a galaxy. It may well be an HII emission region at great distance, or possibly a Herbig-Haro object.

Udo Schlegel
1134 Greenmount Street
Rockford, IL 61107

Fogging Film

Dear Dave:

I've heard about cases where hypered TP 2415 became completely fogged upon development, and I've even experienced that once. Recently I've made a practice of placing a small amount of anhydrous calcium sulfate dessicant in the film canister during both freezer storage and immediately after use; this takes the canister's atmosphere to bone dry and has seemed to prevent even the slightest humidity-induced fogging. Jack Marling seems to agree that this method is an excellent one in minimizing the problem, which is especially bad for those of us who live in high humidity areas such as the Ohio Valley. The dessicant is sold in small 8-mesh crystals in one pound jars.

Tom Eby
2010C Meadowlawn Way
Fairfield, OH 45014

Inside View

A New Beginning

For the last five years, "Deep Sky Monthly" has been a unique source of information for deep-sky observers and astrophotographers. I started it as a labor of love during my sophomore year in high school, and have worked hard to make the magazine something that I and other deep-sky fanatics would enjoy. From the beginning, the project has been a volunteer effort — a small, family-produced publication.

About a year ago, I began to encounter limits. I had only so much time and money to devote to the magazine. It grew into a project that wasn't feasible for one person to do. Production delays were the inevitable result.

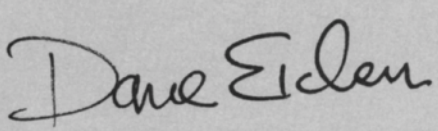
I'm now pleased to announce that the magazine is going to get bigger, better, and much more useful to you. I have been hired as Assistant Editor of ASTRONOMY magazine, and part of my new job is to continue as Editor of DSM. AstroMedia Corp., publishers of ASTRONOMY, ODYSSEY, and TELESCOPE MAKING, now owns DSM and will publish it quarterly, filling it with useful articles and departments that will help you observe and photograph deep-sky objects much better than the old DSM.

As I write this, I am putting together the first 36-page winter issue; I hope that you'll be as excited about the new format as I am. And as always, I will look for your contributions of articles, letters, photos, and observations.

If you are now a subscriber to "Deep Sky Monthly," you will be credited with four of the larger quarterly issues for each eight of monthly magazines you had remaining. The May 1982 DSM was the last in the old series. Suppose you have a subscription for the next year (June '82 through May '83) — you'll receive the next year-and-a-half of "Deep Sky" magazine. I will be doing my best to assure that the quality of the issues will be superior, and can promise that they will arrive on time and will contain much more useful material than the old ones.

If you are new to DSM, I'd like to welcome you aboard at a very exciting time for deep-sky observers. The boom in Dobsonian technology, new films and techniques, and a new awakening to what can be seen outside of our solar system have spurred a new era for backyard observers. There is much to be done; lots to observe, lots to photograph, and a great deal to discuss among viewers of far-away celestial wonders. I'm delighted that we live in this era, and proud that DSM can serve as a forum for our work, projects, and thoughts.

With warm regards,



Dave Eicher
Editor

NGC 2261:
Anatomy of a Nebula
by Francis Reddy

Many of the most interesting objects in the sky are associated with newly formed stars. The suns responsible for the greenish glow of the Great Nebula in Orion, for example, are thought to be a scant twenty thousand years old. Energetic radiation from young embedded stars strips electrons from the atoms in the surrounding gas; fast-moving outflows of material from these young stars — stellar winds — flush out the gas to create delicate filamentary structures. The beauty of such gaseous nebulae is the result of a grand disorder imposed by the stellar youth within them.

A great deal of dust accompanies the formation of a star, and many nebulae are composed of glowing dust instead of ionized gas. Clumps of dust illuminated by the light of a nearby star will shine by scattering and reflecting the starlight. Although reflection nebulae come in a variety of shapes, one class of these dusty objects has the fan shape characteristic of bright comets. Astronomers interested in uncovering the physical processes that accompany star formation are particularly interested in these "cometary" nebulae. In fact, one cometary nebula not only has the singular distinction of being the first object photographed by the 200-inch telescope on Palomar Mountain, but has been studied in detail for 200 years — NGC 2261. If some recent research proves correct, this reflection nebula may be the illuminated portion of a bizarre object best described as an "interstellar nozzle."

Discovered in 1783 by the British astronomer Sir William Herschel, the nebula is triangularly shaped and "points" to the star R Monocerotis. The comet-like tail extends northward two minutes of arc, but the brightest portion is the one arc-minute length nearest to R Mon. The nebula's total brightness is usually estimated at about magnitude 10, and its distance is considered to be about 2,600 light-years based on a presumed membership of NGC 2264, a young star cluster located less than one degree away.

The illuminating "star" at the apex of the fan-shaped nebula is actually a small triangular condensation about five seconds of arc in diameter — a tiny stellar point marks the southern tip. The real R Mon lies enshrouded in dust, either still accreting material or struggling to rid itself of the star-stuff left over from its creation. The object's brightness was found to vary irregularly in 1861. While R Mon usually appears as a magnitude 11 star, it can fade down to 13th magnitude.

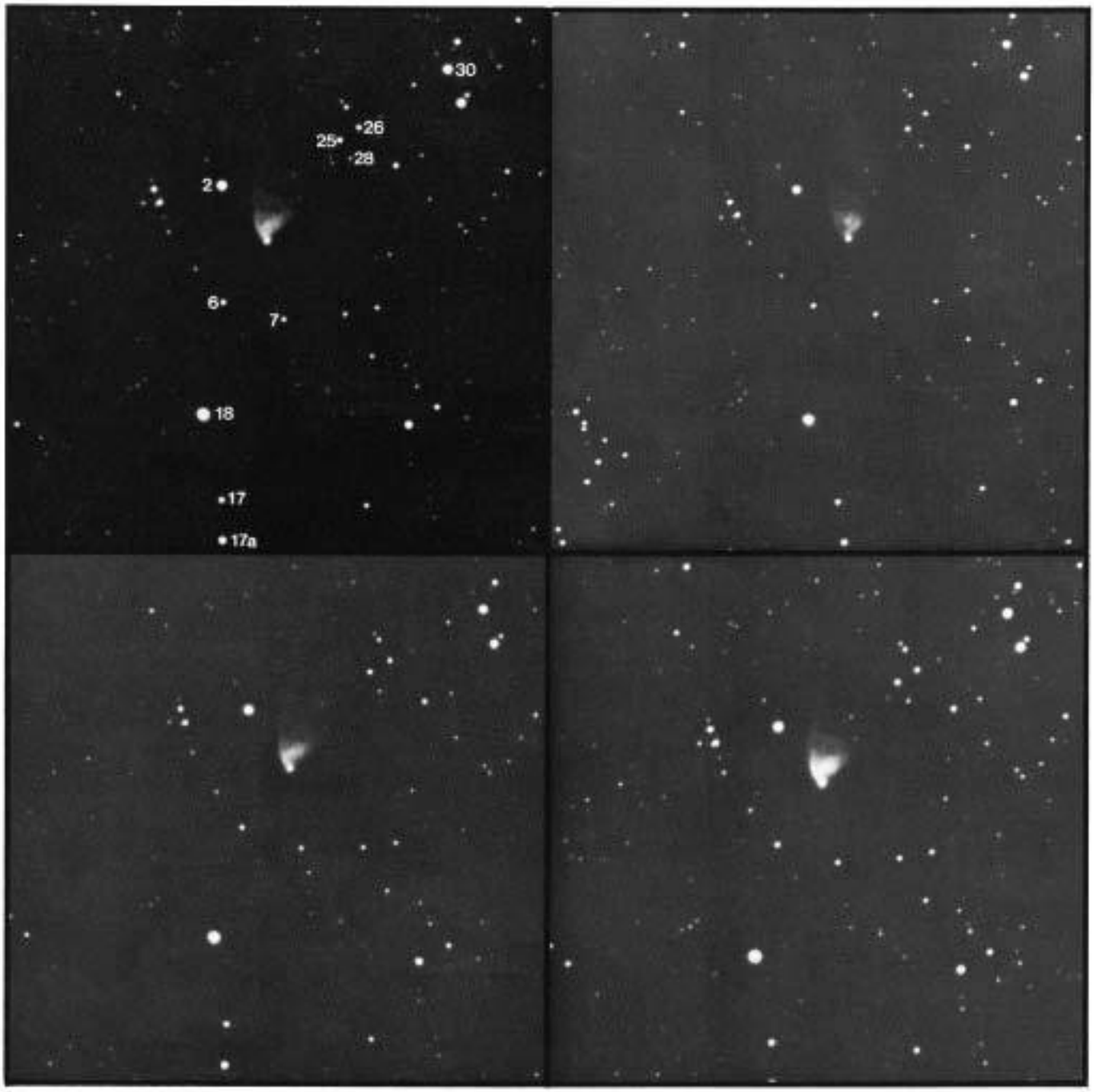
With the exception of a few bright emission lines, the rainbow-like continuum spectrum of R Mon is identical to that of the comet-tail nebula north of it. Clumps of dust illuminated by the light of a nearby star will shine by reflected starlight, so the identical spectra of R Mon and NGC 2261 are most easily interpreted as indicating large amounts of reflective dust. Further proof of dust in NGC 2261 came with infrared measurements made in the mid-1960s. Hot dust should radiate in the long wavelength, low energy region of the electromagnetic spectrum, and R Mon turns out to be considerably brighter in the infrared than at visible wavelengths.

Perhaps the most interesting property of this curious object is that the fan-shaped nebula itself is variable. NGC 2261's variability was first noticed by Edwin Hubble in 1916 while comparing photographs from several observatories; since then the object has been known as Hubble's Variable Nebula. He found that it not only changed in size and brightness, but that various details of the nebula showed changes from month to month.

C.O. Lampland of Lowell Observatory initiated a 30-year study of the object in 1921, taking nearly 1000 photographs. Hubble had believed that the variations were caused by the motion of chunks of matter within the nebula. Lampland's photographs, however, revealed that the apparent displacement of details in the cloud was in some cases as high as one second of arc in four days. This velocity is impossibly high — at the accepted distance of the nebula, the observed motion of material would nearly equal the velocity of light.

Instead of rapidly moving lumps of nebula, Lampland thought that the observed changes in NGC 2261 were caused by variable lighting conditions. He was able to match delicate details on different photographs, and suggested that the nebula really had a permanent structure that only appeared to vary as it faded and brightened. Since R Mon is variable, the nebula that reflects its light should also vary in brightness. Unfortunately, the two objects do not appear to change together. R Mon gradually increased in brightness from 1936 to 1966, but the nebula seemed to fade. That the variations of the nebula would not correspond precisely with those of R Mon might be expected since the starlight must travel to the dust that reflects it. But the nebula would have to be ridiculously large (30 light-years in length) in order to explain the 30-year delay as an effect of the travel time of light. Assuming that the distance to NGC 2261 is correct, the nebula's true length is on the order of one light-year.

Left: Hubble's Variable Nebula photographed with a 36-inch telescope on Kitt Peak. Kitt Peak National Observatory photograph. Above: This is the first official photograph taken with the 200-inch Hale telescope on Palomar Mountain, California, and shows NGC 2261 and surrounding area. Hale Observatories photo.

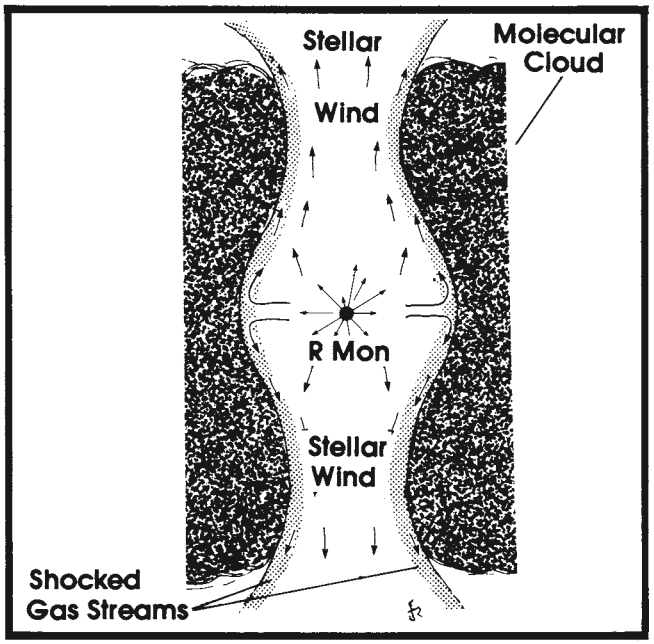


Richard C. Hall made this series of photographs showing changes in NGC 2261's brightness with a 24-inch f/10 telescope. North is up and east to the left in all photos, which were made on IIaO emulsion. The exposures, clockwise from upper left, are as follows: 45 min., 25 Nov. 1976 (showing integrated magnitudes for field stars: 2=mag. 11.3; 6=14.3; 7=14.7; 17=13.4; 17a=11.6; 18=10.2; 25=14.2; 26=14.3; 28=14.5; and 30=11.2); 20 min., 22 Oct. 1965; 50 min. 18 Feb. 1977; and 50 min., 16 Apr. 1979. Northern Arizona University photographs.

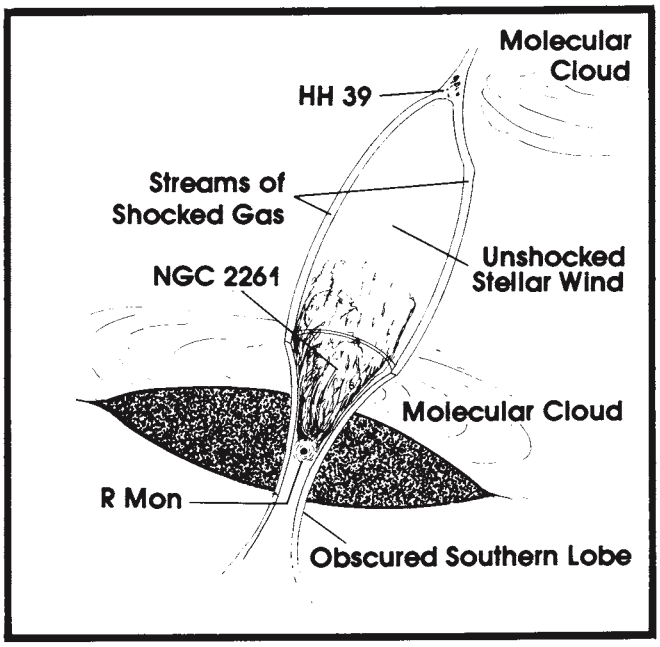
Instead, the variability of R Mon and NGC 2261 can be explained rather simply as a kind of shadow play. Since R Mon is surrounded by material, clumps of dust orbiting the star could pass between R Mon and Earth, blocking the starlight and causing R Mon's variable brightness. Thus the observed changes in the nebula's brightness could be just moving shadows cast on the cloud by dense chunks of material orbiting near the illuminating star. Two other nebulae, NGC 1555 in Taurus and NGC 6729 in Corona Australis, appear to be the projection screens for similar "slide shows."

The moving-shadow interpretation suggests the existence of a large amount of dark material near R Mon, but its extent and distribution has been open to conjecture. The most intriguing model was proposed in 1966 when Frank Low and B.J. Smith suggested that R Mon may be a proto-planetary system, a star surrounded by a disk of dust in which planets could form. In 1981, however, several Mexican astronomers used radiation emitted by carbon monoxide molecules to detect a dense molecular cloud in the vicinity of R Mon/NGC 2261.

Molecular clouds are composed almost entirely of molecular hydrogen, which is 10,000 times more abundant than carbon monoxide. The hydrogen molecule, however, does not emit much detectable radiation. Picture diatomic molecules like hydrogen and carbon monoxide as dumbbells, one atom on each side. Hydrogen molecules have a very symmetrical mass



R Mon's stellar wind has cleared out a nozzle-shaped region in its parent molecular cloud. Shocked gas flows north and south along the nozzle's border.



Dust carried north by R Mon's stellar wind has formed a nebula that shines by reflecting the star's light — NGC 2261. South-flowing dust forms a dusty nebular lobe that is obscured from our viewpoint by the molecular cloud. Shocked gas flows north and south along the sides of the cone, but a molecular cloud 4.5 light-years to the north forces the western stream to collide with the eastern stream. Hot gas at the collision point becomes HH 39.

distribution, but one side of the carbon monoxide dumbbell (the oxygen atom) is more massive than the other. This uneven distribution results in an enhanced ability to emit radio-frequency radiation when the spinning molecule changes from one discrete rotational state to another. In the comparatively dense environment of a molecular cloud, carbon monoxide has plenty of opportunities to change its rotational state through collisions with the more abundant hydrogen molecules. So while hydrogen is the most abundant molecule in the cloud, carbon monoxide is a great deal "noisier."

The molecular cloud discovered by the Mexican astronomers appears to have an elongated shape — about 2.5 by 1.3 light-years in extent — and at its center lies R Mon. The group, led by J. Canto of Mexico's National University, argued that only two spatial configurations could account for this form: a cigar-shaped cloud or a disk-shaped cloud. Although the existence of the molecular cloud is just one piece of a complex puzzle, we can at least begin to understand what is happening in this region.

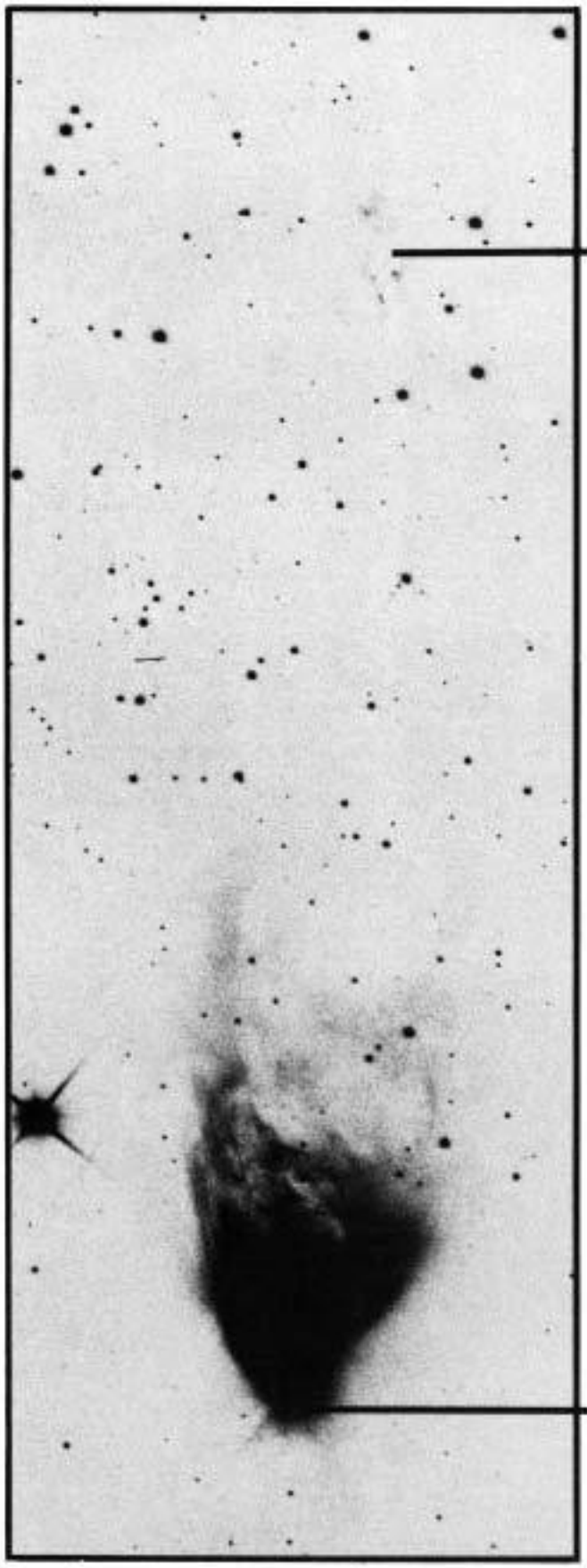
Once a star is born, a gale-force version of the solar wind blows from its surface and pushes out the material that never accreted. Eventually, the charged particles that comprise the stellar wind will clear a channel through the molecular cloud in which the star formed. Material dredged up from the cloud by the stellar wind flows through this channel, and a stream of gas and dust shoots from the cloud. Since there is no significant pressure beyond the cloud to confine the material to a fine stream, the flow broadens as it leaves the cloud, then fans out. In this scenario, then, R Mon is a new star whose powerful wind has punched through the cloud, and NGC 2261, the visible nebula, is a broadened stream of ejected dust.

Canto and co-workers reasoned that the molecular cloud surrounding R Mon must be shaped like a disk, for a cigar-shaped cloud would break into two separate pieces when pierced by the stellar wind. Suppose, then, that the cloud is a disk of material enveloping a central star. The cloud must be stable since it has existed long enough to form a star. A stable disk is likely to be fairly symmetrical, so why has the stellar wind penetrated only the cloud's northern portion? Shouldn't an inverted version of Hubble's Variable Nebula emerge from the south of R Mon?

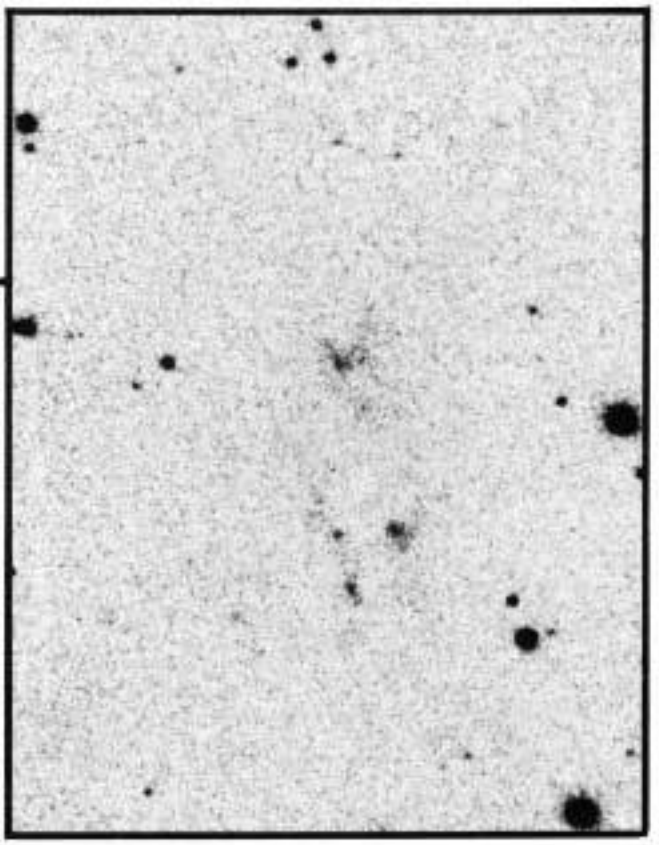
Stellar winds can create two-sided nebulosities. Bipolar nebulae have a configuration similar to that of NGC 2261 except that a fan of gas and dust pokes through both sides of the cloud enshrouding a young star. But in order to understand this region, one more piece of the puzzle must be examined.

About eight minutes of arc north of R Mon, on a line that neatly bisects the nebulosity, lies a tight cluster of faint, diffuse knots called Herbig-Haro 39. George Herbig of Lick Observatory is credited with the discovery of this object in 1968, but evidently Hubble was aware of its existence. Upon examining Mount Wilson plates of the region, Herbig found that "the image of HH 39 had been marked in ink — presumably by Hubble — on at least two negatives taken between 1920 and 1938." There was, unfortunately, no notation on the plate envelopes, so Hubble's opinion of the object is unknown.

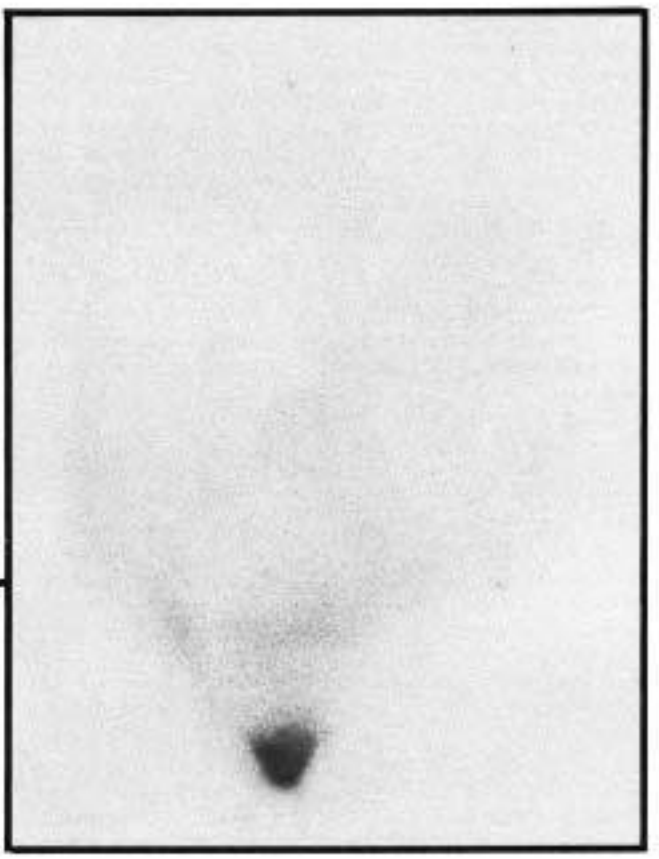
Herbig-Haro 39 belongs to a class of nonstellar objects discovered independently by Herbig and Mexican astronomer Guillermo Haro in the late 1940s and early 1950s. Bright emission lines dominate the spectra of Herbig-Haro (HH) objects, indicating that they consist of glowing gas rather than reflective dust. Atoms that have lost one or more of their electrons are called ions, and the degree to which a gas is ionized (that is, the number of lost electrons) indicates its temperature. Since energy is required to free the electrons from the atoms to which they are bound, highly ionized gas must be extremely hot. This energy is released in the form of light of a specific wavelength when an ion manages to snatch back an electron. Thus HH objects, like other emission nebulae, shine by the light of recombining atoms.



R Mon, NGC 2261, and HH 39 appear together in this contrast-enhanced photograph taken with the 120-inch reflector at Lick Observatory. North is at top, east to the left. All photos on this page were taken with the Lick 120-inch and are reproduced courtesy R.P. Kraft, Lick Observatory.



This enlargement of HH 39 shows the star-like condensations which are characteristic of these objects. Are they "interstellar bullets," ambient gas blobs, or a focused stellar wind?



This short exposure photograph of R Mon reveals its triangular shape and knotty structure.

The problem with Herbig-Haro objects is that they rarely appear near an obvious source of energy. Other emission nebulae, like the Orion Nebula, are clearly associated with hot stars. What is the energy source behind the bright emission lines of HH objects? What is heating the gas?

One idea suggested that HH objects are blobs of gas that happen to lie in the path of a vigorous stellar wind, the culprit star hidden from our view by a dark cloud of material. An energetic wind striking the gas would rapidly increase its temperature, or "shock" it, and gradually accelerate the blobs to the velocity of the wind. As the relative velocity between stellar wind and HH object decreased, the objects would cool and cease radiating, losing their uniqueness.

An alternative interpretation was proposed in 1979 by Colin Norman of Leiden University in the Netherlands and Joseph Silk of the University of California. They argued that HH objects were material ejected by young stars. According to their "interstellar bullet" model, the material is traveling at the same speed as the stellar wind and shocking against the low-density gas in the ambient interstellar medium. Here, then, the energy source for Herbig-Haro objects is the "friction" between rapidly moving gas and the sparse material in the interstellar medium.

The most widely accepted explanation of Herbig-Haro objects is the shock wave model, but Canto and colleagues pointed out a significant problem. HH objects are often all but cut off from the supposed exciting star. The interstellar cloud that completely obscures the star from our point of view almost obscures it from the vantage point of the HH object. As a result, only a fraction of the stellar wind can shock against the HH object. If the stellar wind is assumed to be equally intense in all directions, or isotropic, then the amount of energy carried by the wind to produce the observed heating becomes unrealisitically high since the HH object is exposed to a very small portion of it. According to Canto's group, the carbon monoxide observations suggest that a different mechanism is at work in NGC 2261.

In addition to the molecular cloud enveloping R Mon, the Mexican astronomers also detected radio emission just southwest of HH 39. This indicates the presence of another molecular cloud at a projected distance of about 4.5 light-years from R Mon. They also found Doppler-shifted radio components both north and south of R Mon. The carbon monoxide emission in NGC 2261 was shifted slightly toward the blue relative to the emission from R Mon, indicating that the visible nebula is inclined slightly to our line of sight and material is moving toward us. Canto's group also examined a region just south of the illuminating star and discovered slightly redshifted emission. According to the researchers, this southern emission shows the presence of a fan of dust ejected south of R Mon and hidden from observers by the molecular cloud. "NGC 2261 is not a cometary nebula," claimed the Mexican group, "but one of the lobes of a bipolar nebula."

With the individual pieces of the NGC 2261 puzzle thus laid out, how can they be assembled into a self-consistent picture of the physical processes at work here?

Imagine that a star has just begun to form in the center of a dense molecular cloud, slowly gathering material and collapsing in on itself. The proto-R Mon becomes hotter as its density increases and it continues to grow by the accretion of dust and gas. The temperature of the proto-star's core increases until it begins nuclear fusion, changing its hydrogen into helium and energy. It has become a star.

The star may continue to accrete mass after its nuclear furnace has ignited, but eventually a powerful stellar wind blows from its surface and flushes out the material that never accreted. The wind strikes leftover star-stuff, pushing it away from the star and into the surrounding cloud. At some point, though, the wind is unable to push further into the cloud and it takes the path of least resistance — up the rotational axis of the cloud. This configuration is fairly stable and, assuming that the stellar wind is isotropic, the young R Mon rests in the center of a lower-density region of the cloud that closely resembles a rocket nozzle in shape.

When R Mon's wind strikes the walls of the nozzle, material is carried north and south. Gas and dust carried north on the wind flows out of the disk to form a hollow dusty cone that reflects the light of the hidden star. This northern lobe becomes visible as Hubble's Variable Nebula. South-flowing matter forms the other lobe of a bipolar nebula, but the orientation of the parent molecular cloud prevents us from seeing it.

The vigorous wind also shoots a fine stream of shocked gas out of the nozzle, according to the model proposed by the Mexican group. Gas is shocked when the rapidly flowing wind strikes the dense cloud. As it leaves the cloud, the conical stream of gas remains shocked owing to friction with the low-density interstellar medium; interior pressure from the stellar wind maintains the stream's conical shape. Wind pressure decreases as the shocked stream moves farther away from R Mon, so the cone begins to narrow. This focusing process is hastened by the presence of another molecular cloud about 4.5 light-years north of the young star. The western side of the cone smacks into the northern cloud and refracts into its eastern side. The low-density gas streams collide and become hotter — and HH 39, a group of gaseous knots at the point where the streams collide, represents shocked gas radiating light as it cools.

Canto's group proposed this focusing mechanism to explain the apparent lack of acceptable energy sources for the Herbig-Haro object. Once the shocked streams collide, cooling gas should move away at the full velocity of the stellar wind at that distance. This scenario illustrates the powerful effect of a young star on its environment and an intimate connection between several puzzling objects — but is it correct?

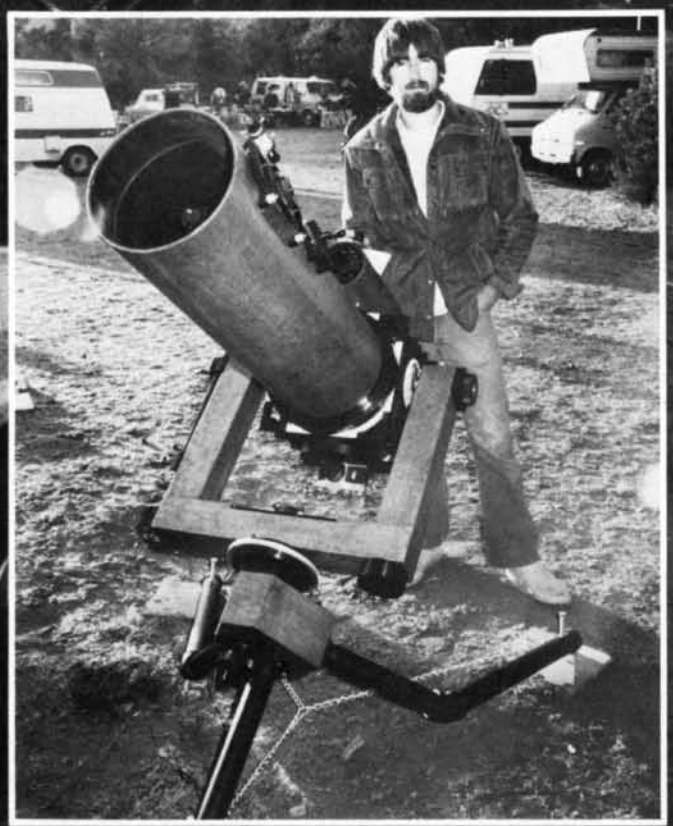
Lick Observatory astronomers Burton Jones and George Herbig recently examined the region in detail. According to their results, the knots in HH 39 are moving across the plane of the sky at the full velocity of the stellar wind (about 300 kilometers per second). Since the high-velocity knots of HH 39 are traveling at or very near the terminal velocity of the R Mon wind, they note that "in this case the luminosity of the knots cannot be explained as a stellar wind shocking on slow-moving interstellar clouds in its path."

Jones and Herbig, however, argue that HH 39 is an "interstellar bullet" rather than a focused stream of shocked gas. An implication of this suggestion is that HH 39 cannot have slowed down significantly since it was launched by R Mon because both the wind and the gaseous knots now have the same velocity. Since the present velocity must be valid for most of the flight time, HH 39 was shot from R Mon about 6000 years ago — if it was shot out at all.

The relationships between R Mon, NGC 2261, and HH 39 have perplexed astronomers for the better part of this century. Although the disruptive effects of star formation are clear, the actual processes involved in the making of a star — particularly in this region — are far from being understood. We can say for certain, though, that R Mon is a young star vigorously clearing out the material that formed it, a star that strongly affects a region up to 5 light-years distant with the stellar gale it blows. This fascinating object is telescopically interesting, appearing as a fuzzy triangular patch in most backyard instruments. As you observe Hubble's Variable Nebula on a quiet evening this winter, think about what it's doing; the calm eyepiece view will masquerade the violent processes taking place, but you'll certainly know what this celestial showpiece is really up to.

Riverside '82

by Kevin Ritschel



George Balazs and his award-winning 10-inch f/5.5 Newtonian.

Cliff Holmes and Pat Michaud address attendees.

Big Bear by moonlight

All photographs (unless otherwise noted) are by John Sanford

Above: Jack Marling talks with fellow astrophotographers about current trends, films, and equipment. Right: Coulter Optical Co. shocked nearly everyone with their 29-inch "Odyssey" telescope which retails for about $3000. Riverside goers viewed M13, M57, the Veil Nebula, and other objects with the giant scope, and found it to give enjoyable views. Coulter has even mentioned larger telescopes for the future!

The end of May brings about many changes and events for amateur astronomers on the West Coast: the end of cold observing nights, the welcomed early rising of the summer constellations (and their deep-sky treasures), the end of school, and the Big Bear Riverside Telescope Makers' Conference (RTMC).

This festive gathering of enthusiastic astronomers started several years ago as the brainchild of Clifford Holmes, who wanted a way in which amateurs could come together to share the sky (and, subsequently, ways in which to view it). It began on a small scale and has improved each year so that it is now the largest such gathering west of, well, . . . Stellafane! As its name suggests, the main purpose for the conference is the discussion of telescope making; all facets of the hobby are represented, however. Plenty of instruments are brought each year to be entered into the competition which occurs during a two-day period of talks. Amateur papers primarily include discussions of astronomical engineering and telescope design. This year an experiment was tried: three "group discussions" detailing optics, mountings, and astrophotography. These events (which are also conducted at Stellafane and the Texas Star Party) allow a free interplay of ideas between all present. This dialogue permits, as Richard Berry of "Astronomy" suggests, an outline and "blueprint" of a telescope design to be made before construction starts. If you are only interested in viewing faint deep-sky objects, the construction of a large Dobsonian telescope is by far the most cost-effective method for you; you needn't spend a carload of money on an ornate 8-inch or 10-inch reflector or large refractor. You can pick and choose from designs as you like; enough exist that you can tailor one for your specific observing interest.

The Riverside Conference is held high in the San Bernadino Mountains near Big Bear Lake, California. The weather is usually favorable, and this year was no exception. The skies were clear but a waning moon stifled observing, save for those hearty telescopists who greeted the dawn. Southern California, indeed the entire southwestern United States, is normally blessed with good seeing conditions. I felt that this year I'd never seen such

an outstanding combination of excellent transparency and terrible seeing. Viewing, even at low magnifications, revealed stellar images that resembled bloated planets. The field of view looked as though it had been painted on the bottom of a swimming pool. It was indeed unfortunate as there were several 6-inch and 8-inch refractors present capable, under good seeing, of delivering magnificient planetary images.

This year Riverside saw several trends which have continued from last year, the development of which is always exciting. Large-diameter mirrors are getting to be very common! Present were many 14-inch and 16-inch reflectors and a number of 17.5-inch, 20-inch, and 24-inch telescopes. The advantage of observing with large-aperture optics is obvious, but the mirrors must be made and mounted very well. Of special interest was the first public showing of Coulter Optical's 29-inch Odyssey "Super-Dobsonian." These telescopes have made it big during the last few years; they are cheap, very simple to construct, simple to use, and very effective on deep-sky targets. Nobody has made a Dobsonian larger than Coulter's new "Cosmos-1." It was startling to attendees that such a huge instrument could be offered for a (mere) $3000. Even more amazing is the fact that Coulter plans to offer even larger scopes in the future. However, your desire for additional photon-collecting shouldn't distort your sense of practicality (if it can be claimed that amateur astronomers are practical!). The views through the 29-inch were very enjoyable; moving it around wasn't. It took a truck with a 20-foot bed to lug the scope up the mountain.

Left: A triple exposure illuminates this finely crafted 17.5-inch f/4.5 Dobsonian made by Don Raether and Carl Blue. Above: Byron Melland (shown) and Dave Chandler made this 24-inch reflector for less than $500. Photo by Don Lynn. Below: Eleanor Helin of Caltech spoke on asteroid observations.

LIST OF AWARDS: RIVERSIDE 1982

Clifford Holmes Award for long-term contribution to amateur astronomy: Dennis di Cicco, Assistant Editor, "Sky and Telescope" magazine, Cambridge, Massachusetts.
Warren Estes Award for best use of simple materials: Don Machholz, San Jose, California, for his 10-inch f/3.8 comet-seeker.
Junior Award: Jude Solomon of the Chabot Telescope Makers for his 6-inch telescope.
Best Metal Craftsmanship: Steve Clark of the Riverside Astronomical Society for his single fork mount arm and telescope.
Most Improved Telescope: Rick Shaffer, who converted his 18-inch Dobsonian (shown last year) to a much more transportable compact design.
Best Use of Wood: Don Raether and Carl Blue of Garden Grove, California for their 17.5-inch Dobsonian which uses an aircraft-type monocoque wood construction.
Novel Use of Materials: Tom Scott and Terry Boone of Fresno, California for their 20-inch f/5.2 scope which has a tube made of welded-together 50-gallon oil drums.
Innovative Ideas: David Wile of Santa Monica, California for his simple Newtonian which disassembles into small pieces for transportability.
Daring Drive Concept: George Scotten and Chris Houghton of Vermont for their "porch-swing"mounted scope with Wright-Schmidt optics.
Best Use of Materials: Byron Melland and Dave Chandler for their 24-inch fork-mounted disk-driven telescope which was made for less than $500.
Excellence in Workmanship and Innovative Ideas: Dick Nelson for his "Alohalani 1," a 10-inch transportable telescope that easily disassembles for transport.
Innovative Craftsmanship: George Balazs of Phoenix, Arizona for his wooden veneer tube and wooden fork for his 10-inch f/5.5 Newtonian.
Best Observing System: Steven Kysor for his computer-controlled Dobsonian and observing desk.
Craftsmanship and Use of Materials: David Pitou for an 8-inch f/15 Maksutov telescope.
Excellence in Workmanship: Gerry Logan for his 8-inch f/6 Jones-Bird telescope.
Honorable Mention: John West for contribution in electronics to crystal-controlled oscillator design.

Unloading and assembling the telescope was relatively easy, although it took about 10 people to do so. The Cosmos-1 may not be the ultimate personal telescope, but for a club of dedicated observers (or for the single observer who can affix it in a single location), the 29-inch should definitely be considered.

Once again wood was demonstrated to be a highly effective material for building telescopes. Many examples of excellent wood craftsmanship were displayed.

Amateurs often play interesting games in trying to make their scopes portable. Several trailer-mounted units were shown, as well as many instruments that were capable of easily breaking-down in many components.

Many anticipated that electronic instrumentation would make a big splash this year. It did not. Although the "electron plumbers" were represented in force and the IAPPP held a meeting at the same site, we still had no automatic telescopes. Electronic aids will surely play a big part of the future of telescope making, but the cost of experimentation at this point is largely prohibitive.

The Riverside conference always has its share of commercial and non-commercial displays. Indeed, one of the highlights of such gatherings is the opportunity to see hardware from manufacturers, see new products before purchasing, and compare units made by different companies. Some participants feel that such commercial displays are not useful at conventions; I feel that the above mentioned reasoning (and the added "spice" of door prizes) outweighs any potential harm caused by such participation by manufacturers.

The future of large meetings such as the RTMC is not in doubt. The energy and ideas reaped from such gatherings seems to make observers long for the next one, perhaps for the chance to display their telescope, their astrophotos, or talk to knowledgeable amateurs. As the popularity of amateur astronomy grows, so does the usefulness of a few days spent in California under the stars.

Star Trails

Left: Marty Germano photographed NGC 7243 with his 8-inch f/10 Schmidt-Cassegrain, 103aF film, and a 30 minute exposure. Right: Using the 13-inch f/5 "Pluto" camera, Brian Skiff exposed for 30 minutes on 103aO to show northern Lacerta. Lowell Observatory photograph.

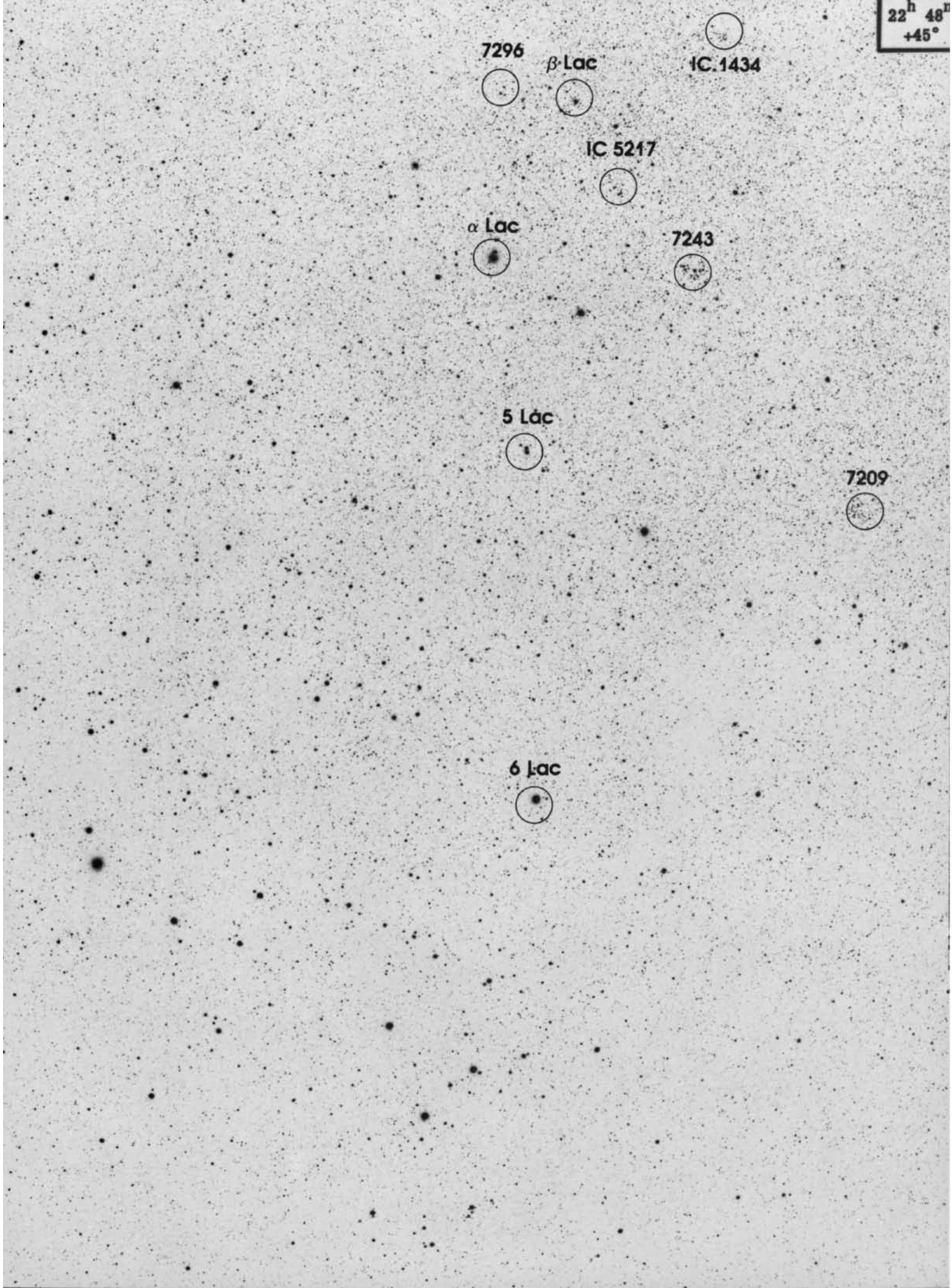
Lacerta: Milky Way Clusters and Far-Off Galaxies

by Brian Skiff

Between the Andromeda Galaxy and Deneb on the east and west, and the Milky Way and Square of Pegasus on the north and south, is a tract of sky which seems a bit neglected in the popular astronomical literature. Perhaps the lack of bright offset stars is responsible, as indeed there are hardly any recognizable patterns in this area. A kinky string of faint naked-eye stars forms **Lacerta**, the Lizard, near the middle of this tract, and here lie several interesting objects, only a couple of which have received any notice. The constellation boundary is similar in shape to the outline of New Hampshire, and occupies about 10° of width and some 20° of height. The southern section is far enough from the Milky Way that many galaxies are able to shine through, while the northern half is solidly immersed in rich star fields, and several clusters appear. The center of the constellation culminates at 8:00 on 28 October, and a half-hour earlier for each succeeding week.

The galaxies I have been able to find are clustered at the bottom of the constellation near 1 Lacertae. They are only about 15° from the galactic plane, and thereby suffer about two-thirds of a magnitude of absorption by the Milky Way. **NGC 7242** is the brightest of a group of galaxies with redshifts of about 6000 km/sec, corresponding to a distance of 80 megaparsecs (which equals 260 million light-years, assuming the Hubble Constant H_o =75 km/sec/Mpc). In a 10-inch (25cm) instrument, I saw a large haze

7226
K9
7245
I1442
I1434
296


22h 48h
+45°
7296
β Lac
IC.1434
IC 5217
α Lac
7243
5 Lac
7209
6 Lac

This plate from the "Lick Observatory Sky Atlas" was made with a 5-inch f/7 lens and 103aO emulsion. It shows a portion of central Lacerta, including many of the objects discussed in the article. Lick Observatory photograph.

elongated north-south set in a field of many 13th magnitude stars. Just to the west is the faint pair of galaxies **NGC 7240** and **IC 1441**. NGC 7240 is much smaller than 7242, appearing as a diffuse hazy spot in a 10-inch scope at 190x. IC 1441 lies 1.2' northwest, and I was not sure I could discern it.

About 3° north is another brighter pair of galaxies, but I could not see either galaxy with a 6-inch (15cm) stop over the 10-inch Newtonian. **NGC 7248** is fairly faint even in a 10-inch scope, with an overall size of 40" x 20" in p.a. 120°. Its small oval core seems to hold some subtle detail. Two double stars lie close by to the west (magnitudes 12 and 13, separation 7", p.a. 305°) and east (12 and 12.5, 12", 80°). Some 17.5' northeast is **NGC 7250**, a pretty faint object on the northwest side of a magnitude 11.5 star. The lenticular glow is elongated in p.a. 65° and has a magnitude 14.8 star on its northwest tip. The central two-thirds has some definite mottling.

NGC 7209 is the first of the open clusters in Lacerta. A dim but adequate view may be obtained with a 2.4-inch (6cm) or 3-inch (7.5cm) refractor. In a 6-inch aperture it is an attractive group about 20' in diameter with 40 stars, many arranged in right-angled patterns. Two magnitude 8.5 stars lie on the west and southwest, while a magnitude 7 star (yellow or red?) is to the north. The 10-inch shows 75 stars in a 15' diameter, and many more outlying stars extending to 25'. The stars are of magnitude 10.5 and fainter and exhibit little concentration toward the center.

Another large bright cluster is **NGC 7243**, which should be a nice sight in small apertures. Observations available to me (three observers and apertures) and those in the "Webb Society Handbook III" all indicate an elongated shape when discussing this cluster, but interpretations differ. A conspicuous grouping is arranged in a 'C' shape, parabolic arc, or just a triangle about 20' across, opening to the north. On the east side of the curl is a nice pair (10 and 10.3, 10", p.a. 350°, bluish?). In the 10-inch about 25 stars are involved in the arc. To the east and north are another 40 fainter stars seemingly associated with the cluster. In a 25' x 18' area (elongated in p.a. 60°), a friend using a 12-inch Cassegrain has counted 80 stars.

The open cluster **IC 1434** is a treat for observers with large instruments and dark skies. Using a 6-inch scope at 100x to 125x, it appears as a grainy patch of stars at the limit of visibility. It is partly ringed by some brighter stars, with one outstanding star on the north edge. At lower powers with a 10-inch scope, the cluster also appears hazy. Two long rays of stars are conspicuous, curving east-northeast and west-northwest. At 190x, at least 100 stars are resolved within a 20' circle, mostly fainter than magnitude 12.5. Three brighter stars form a triangle south of the cluster's center.

NGC 7245 is a smaller, fainter cluster. In the 10-inch at 190x about 40 stars can be seen in a 6' diameter with a very slight haze. The stars are fainter than magnitude 13.0 — fainter than the ones in IC 1434 — and unconcentrated toward the center. On the east side of the cluster is a dark bar measuring about 5' x 1' in p.a. 30°; a few stars appear on its eastern side, detached from the main body of the cluster. The description and sketch in the "Webb Society Handbook III" for 7245 indicates that the observers correctly identified the field, but really saw nothing of this cluster. To the northeast is an 11th magnitude star, and on its north side is the cluster **King 9**. I was not able to see it with a 10-inch telescope, and really shouldn't have expected to. The brightest stars in it are only of magnitude 18 according to its discoverer, suggesting a total magnitude of about 16. A few stars show on the accompanying photo, which reaches a little below magnitude 18.

About 20' south is the sparse group **IC 1442**. In the 10-inch scope, it appears to be about 10' in diameter, with 35 stars scattered mostly north and west of a magnitude 10.5 star. The stars vary widely in brightness, and seem to be only a slight condensation in a very rich field. To the north are scattered 11th and 12th magnitude stars which bridge across to the region of 7245.

Less than a degree east of β Lacertae is **NGC 7296**. In a 6-inch scope about a dozen stars are resolved, concentrated into an area less than 5' across. With a 10-inch scope I counted 19 stars in an area measuring 2.5' across, including a magnitude 10.5 star on the west edge.

Our final Lacerta object is the small planetary nebula **IC 5217**. Difficult to locate except at high power, it lies 2' north of a magnitude 11.5 star. In the 10-inch scope it is clearly elongated north-south with a stellar center (probably not the central star). The color is grey or blue-grey. In one observation I detected a sharp taper like a football at the southern end.

Reader observations of these objects are welcome for future issues.

421 West Aspen
Flagstaff, AZ 86001

Objects in Lacerta

	Name	R.A. (1950)	Dec.	Size	Mag.	Sfc.	Type	Notes
O	NGC 7209	22h03.2m	+46°15'	25'	7.8	—	III1p	
O	IC 1434	22h08.6m	+52°35'	8'	9.0	—	II1p	
§ſ	IC 1441	22h13.1m	+37°03'	0.9x0.4'	15.3z	—	SBa?	1
§I	NGC 7240	22h13.1m	+37°02'	0.8x0.8'	14.9	14.2	SO⁻:	2
O	NGC 7243	22h13.3m	+49°38'	21'	6.7	—	IV2p	3
O	NGC 7245	22h13.4m	+54°05'	6.5	11.5	—	II1p	4
§S	NGC 7242	22h13.5m	+37°03'	2.6x2.0'	13.1	14.8	SA(r)0:	5
O	King 9	22h13.6m	+54°09'	2.5'	14	—	I3m	6
O	IC 1442	22h14.6m	+53°48'	3.5'	—	—	II2m	7
§S	NGC 7248	22h14.7m	+40°15'	2.1x1.1'	13.6z	—	SAO⁻:	
§I	NGC 7250	22h16.1m	+40°20'	—	13.1z	—	—	8
■	IC 5217	22h21.9m	+50°43'	7x6"	12.6p	15.5v	—	9
O	NGC 7296	22h26.2m	+52°02'	4.0'	9.7	—	III2p	

Notes: [1]1.2' northwest of NGC 7240; [2]B-V = 1.1; [3]**AJ**, 76:110, contains photometry and spectra; [4]**Ast. and Ap.** 8:213 contains photometry; [5]the brightest of its group. B-V = 1.1; [6]its stars are very faint (about magnitude 18); [7]**Ast. and Ap.** 8:213 contains photometry; [8]lies 17.5' northeast of NGC 7248; [9]V central star magnitude from J. Kaler, 1978, **ApJ**, 226:947.

Data for open clusters from G. Lynga, 1981, **A Catalogue of Open Star Cluster Data**, except for a few bits in the cited papers. Galaxy data are from de Vacouleurs, et. al., 1976, **Second Reference Catalogue of Bright Galaxies**. Magnitudes are in the B system, except those marked with a **z**, which are from Zwicky's **Catalogue of Galaxies and Clusters of Galaxies.**

Coding:
O open cluster
■ planetary nebula
§S spiral galaxy
§ſ barred spiral galaxy
§I lenticular galaxy

Double Star Observing

by Glenn F. Chaple, Jr.

A Beginner's Introduction

Imagine the surprise Jean Baptiste Riccioli must have felt when, in 1646, he trained his telescope on the star Mizar. Instead of the one star visible to the naked eye, he saw two! Riccioli had accidentally discovered the first double star. In the 330-odd years since then, thousands of additional double and multiple stars have been discovered. Today, as in Riccioli's time, the delicate beauty of these stellar duos dazzles the eyes of the telescope owner.

Up until the latter part of the 18th century, astronomers thought that the components of a double star were actually quite distant from each other. Their apparent closeness was explained as an illusion arising from the fact that the two stars just happened to lie along the same line of sight as viewed from the Earth. But visual studies of double stars by Sir William Herschel finally put this idea to rest. By observing the positions of the components of the double star Castor, Herschel found that they were in motion around a common center of mass. Astronomers soon discovered that most telescopic double stars are, like Castor, true binary systems, which comprise the majority of all stars in galaxies.

When you look up the description of a double star, you'll usually encounter three pieces of information: the magnitudes of the components, their angular separation, and the position angle of the pair.

The magnitudes, of course, refer to the brightness of each of the two stars. A double star whose components are similar in brightness is much easier to resolve than one whose members differ by more than 3 or 4 magnitudes. In the latter case, the dimmer member is usually lost in the glare of its brighter partner.

The angular separation is how far apart the two stars appear to be, and is measured in seconds of arc. One arc-second is $1/3600$ of a degree and is approximately equal to the width of a penny viewed from a distance of two-and-a-half miles! Under ideal conditions, a good 3-inch telescope will split a double star whose components are only 1.5" apart, assuming that the components are of equal brightness. A 6-inch does even better, splitting pairs that are separated by only 0.8". Close doubles are popular with astronomers who like to put the quality of their telescope optics to the ultimate test.

Position angle defines the position of the dimmer star in the system in relation to its brighter partner. The angle is measured eastward from north — north is 0°, east 90°, south 180°, and west 270° — and it can be quite useful in identifying pairs in small telescopes.

How does the beginner undertake a program of double star observing? The equipment is simple — a small telescope and a basic familiarity with the constellations. A star atlas or map can be of great value. Even the skilled observer can "get lost" while scanning the skies for a particular deep-sky object. It is a good idea to start with fairly wide double stars — those separated by 8" or more, since these are fairly easy to split. As you gain experience, you will soon be able to tackle the close pairs that cause eyes to water and hands to tremble.

From the hundreds of double stars that may be seen with small telescopes, I have selected 10 to help you get started. All are easily located with small telescopes and are easily resolved with telescopes as small as 2 inches' aperture. A few are beautiful enough to be considered true celestial showpieces. For best results, use a low power eyepiece (25x-50x). Good luck — and remember, double stars are twice the fun!

A Beginner's List of Double Stars

ζ **Ursae Majoris** -"Mizar" (mags. 2.5 and 4, sep. 14", p.a. 151°). This is the one that surprised Riccioli over three centuries ago. It is probably the easiest double star to locate, since it is the middle star in the handle of the Big Dipper.

ν **Draconis** (mags. 5 and 5, sep. 62", p.a. 312°). The faintest star in the head of the Dragon. A beautiful wide double, best seen with low power. It can even be split with binoculars.

β **Cygni** - "Albireo" (mags. 3 and 5.5, sep. 35", p.a. 54°). One of the finest sights in the heavens, this pair combines a yellow star with a bluish one. the contrast is obvious to even the most inexperienced observer. Albireo is the star that marks the "base" of the Northern Cross (or the "nose" of the swan).

θ **Serpentis** (mags. 4.5 and 5, sep. 22", p.a. 103°). A closer version of γ Draconis, this lovely double is located at the tip of the Serpent's tail.

β **Scorpii** - "Akrab" (mags. 2.5 and 5, sep. 14", p.a. 23°). This star is similar in appearance to Mizar. Many observers describe the fainter member as having a bluish to blue-green tint. What color do you see?

γ **Andromedae** - "Almach" (mags. 2.5 and 5, sep. 10", p.a. 63°). A beauty! Orange and blue stars present a vivid color contrast.

γ **Delphini** (mags. 4.5 and 5, sep. 10", p.a. 268°). This star forms the tip of the Dolphin's nose. Some color contrast may be visible.

γ **Arietis** - "Mesarthim" (mags. 4.5 and 4.5, sep. 8", p.a. 360°). A beautiful "twin" double. Both stars seem whitish.

α **Ursae Minoris** - "Polaris" (mags. 2 and 9, sep. 18", p.a. 218°). Because Polaris is our north star, it may be seen on any night of the year. Note the large magnitude difference between its components; unless skies are clear and steady, Polaris will prove to be a difficult object for small telescopes.

θ **Orionis** (mags. 5, 6, 7, and 8, sep. 13", 13", and 17", p.a. 61°, 311°, and 342°). I just had to close this list with a multiple star, and what could be more beautiful than this heavenly "baseball diamond" fully immersed in the great Orion Nebula? The Trapezium — as this stellar foursome is called — together with its parent nebula, is one of the grandest of all sights for the sky-watcher.

Sources of Information for Double Star Observers

Binary and Multiple Systems of Stars by Alan H. Batten. Pergamon Press, New York, 1973. Batten outlines the astrophysical nature of double stars in topics such as periods, masses, radii, stellar atmospheres, and the evolution of binaries.

Burnham's Celestial Handbook by Robert Burnham, Jr. Dover, New York, 1978. This work provides a huge amount of data and observing information for several thousand double stars, as well as data for other deep-sky objects.

Double Stars by Wulff D. Heintz. D. Reidel, Boston, 1978. The Swarthmore College professor presents a monographic text on the physical nature of double stars.

Observational Astronomy for Amateurs by J. B. Sidgwick. Enslow, Short Hills, NJ, 1982. This revised edition of Sidgwick's classic provides some useful information in its short section on binary stars.

Observing Visual Double Stars by Paul Couteau. MIT Press, Cambridge, MA, 1981. Couteau's work is an excellent guide to observing doubles.

Properties of Double Stars by Leendert Binnendijk. University of Pennsylvania Press, Philadelphia, 1960. Another astrophysical book, this work primarily outlines spectroscopy, photometry, and the nature of

eclipsing variables.

Webb Society Deep Sky Observer's Handbook: Volume 1, Double Stars by Robert W. Argyle, edited by Kenneth Glyn Jones. Enslow, Short Hills, NJ, 1979. This is a superb observing guide for double stars that presents a catalogue of 522 doubles and multiples.

Viewing Close Doubles with Small Telescopes

I won't soon forget that spring evening when I split my first close double star. I was an inexperienced observer who had never resolved a double star closer than 7" with the 3-inch reflector I used. The evening's excitement began when I managed to glimpse both components of ζ Cancri, separated by just 6". Moments later I managed another triumph, this time with θ^2 Cancri, also a 6" pair. Encouraged by my success, I trained my telescope on an even greater challenge — the 4" pair γ Leonis. What a thrill to see the shimmering image settle into two distinct points of light! Since that memorable night I have resolved a number of even closer doubles with the same telescope, but few have produced the elation I felt over splitting that gem.

If you own a small telescope, close double stars offer you a unique challenge. One measure of your observing skill and the quality of your optics can be judged by your successes and failures with such pairs. When should you shift your efforts from such wide, easy pairs to their close, patience-testing counterparts? Before deciding, consider the following points: (1) the amount of observing experience you have, (2) the limitations of your telescope, and (3) your awareness of the effects of sky conditions.

It is not wise to seek out close double stars until you have had a reasonable amount of observing experience. This should include practice on some wide doubles so that you will have an idea of what to expect from the close ones. Your observing time during this "training period" will also prepare your eyes for close double stars by actually increasing their sensitivity to starlight. Where direct viewing fails, you will learn how to use "averted vision" to locate faint companion stars. Above all, experience will have taught you to appreciate the value of your eyes as the most important piece of observing equipment you have. Once you are confident in the operation of your telescope and can locate and resolve wide double stars with ease, you can set your sights on close double stars.

It is important for double star observers to understand the limitations imposed by the instruments themselves. The Rev. William R. Dawes produced a formula that roughly defines the closest double star a telescope can resolve. This celebrated 19th century amateur astronomer merely divided the telescope's aperture (in inches) into the number 4.56. The answer, expressed in seconds of arc, and known as "Dawes' Limit," works only for bright doubles whose components are roughly equal in magnitude. Still, it is a good guideline to help you avoid chasing down double stars that are beyond the grasp of your telescope.

Sky conditions are also an important factor, and consist of two elements — transparency and seeing. Transparency refers to the clarity of the sky and ranges from being totally overcast, to hazy, to the clearest possible skies. Seeing is a measure of how steady the atmosphere is. When seeing is poor, air turbulence is evident by the pronounced twinkling of naked-eye stars and the "boiling" of star images in the eyepiece of the telescope. With good seeing, naked-eye stars shine steadily and a star's telescopic image is sharp, even at high powers. Such an all-too-rare evening is the ideal time to work on double stars that approach the Dawes' Limit of your telescope.

Let's say you've had experience with wide double stars, know the limits of your telescope, and expect some beautiful skies in the evenings ahead. Then it's time to set up your telescope and try it out on some close double stars. The box describes only 10 of the dozens of close pairs that will test the skills of the small telescope user. A good star atlas like Tirion's "Sky Atlas 2000.0" will show their location. Use high power — 120x to 150x should do the job. With luck, you'll train your telescope on each one and — see double!

Some Close Doubles for Small Scopes

χ **Ursae Majoris** (mags. 4.5 + 5.0, sep. 2.9", p.a. 129°) A rapid binary that completes one orbit in 60 years. Its separation is rapidly decreasing.

γ **Leonis** (mags. 2.6 + 3.8, sep. 4.3", p.a. 123°) The brightest star after Regulus in the Sickle of Leo.

γ **Virginis** (mags. 3.5 + 3.5, sep. 4.0", p.a. 306°) A beautiful "twin" system that is presently closing. Discovered in 1718.

α **Geminorum** - Castor (mags. 2.0 + 2.8, sep. 2.2, p.a. 140°) Considered by many astronomers to be the finest double star in the northern sky.

α **Piscium** (mags. 4.3 + 5.2, sep. 1.8, p.a. 292°) A difficult object for my 3-inch reflector.

μ **Draconis** (mags. 5.8 + 5.8, sep. 1.9, p.a. 66°) Right at the Dawes' Limit for a 2.4-inch refractor.

70-Ophiuchi (mags. 4.1 + 6.0, sep. 2.0, p.a. 72°) Another rapid binary — completes a cycle in 88 years. This system is a neighbor of our Sun, lying only 17 light-years away.

σ **Cassiopeiae** (mags. 5.0 + 7.1, sep. 3.0", p.a. 326°) This is a difficult target because of the magnitude difference between the star's components.

2 Equulei (mags. 7.1 + 7.1, sep. 2.6", p.a. 218°) A good "test" because of its location in a faint constellation.

ϵ^1 **Lyrae** (mags. 4.6 + 6.3, sep. 2.9", p.a. 173°)

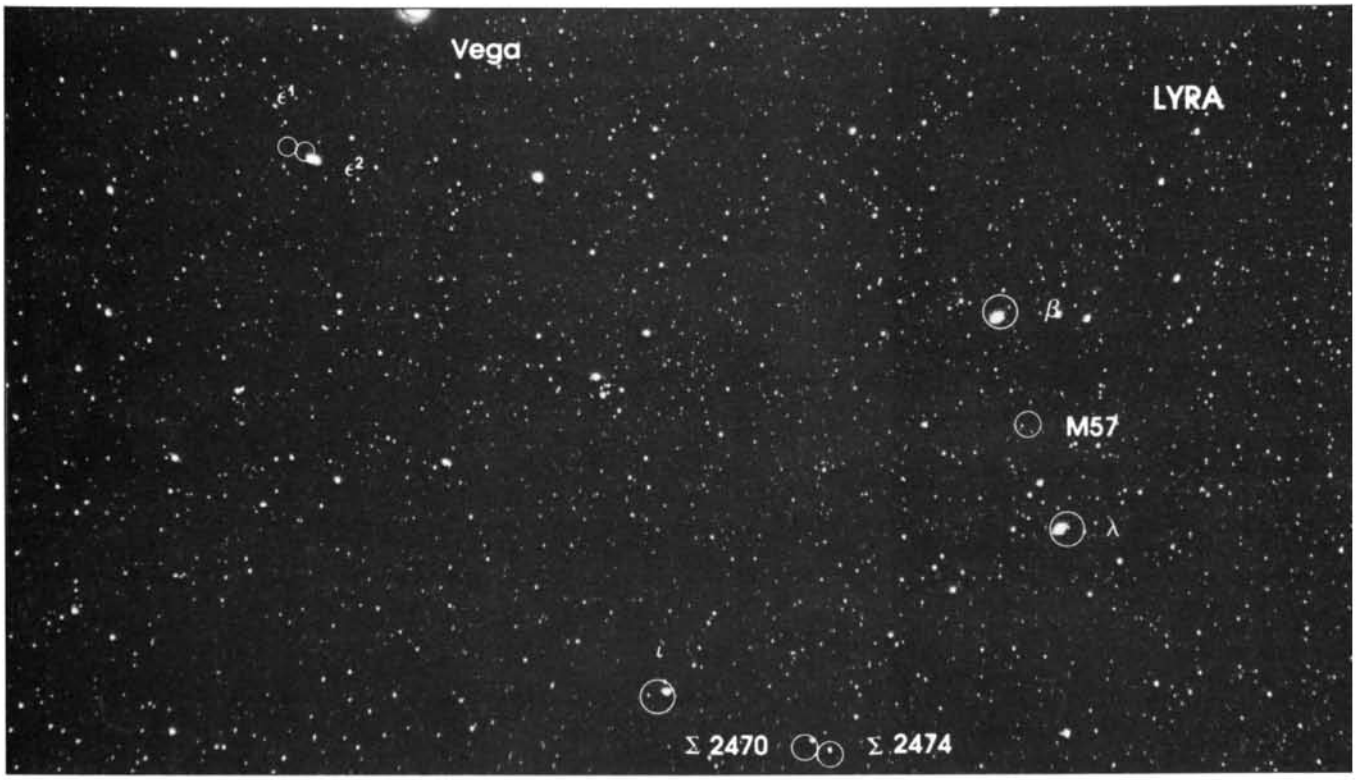
ϵ^2 **Lyrae** (mags. 4.9 + 5.2, sep. 2.3", p.a. 98°) A grand "double-double," ϵ^1 and ϵ^2 form a wide binocular pair, separated by 208".

The "Double-Double"

There's a TV commercial for a product that is supposed to "double your pleasure." You know: two dogs chewing on a mailman's leg, a two-headed monster at a double feature, twin cheerleaders, and so on. The final pitch is that the greatest "double" of all is a big wad of gum. Well, it's just too bad the average viewer knows so little about astronomy! After all, they've omitted the "double-double" — Epsilon Lyrae.

Look at **Epsilon Lyrae** (situated 2° northeast of Vega) with binoculars or through your finderscope. You'll see two 5th magnitude stars with a 3.5' gap between them. This is hardly an "ultimate double," but, as you might suspect, there is more. When viewed with a telescope and a magnifying power of at least 100x, each star is again doubled! Epsilon Lyrae, as all veteran skywatchers know, is the celebrated "double-double" — as ultimate a double as you could ask for.

The multiplicity of Epsilon Lyrae was revealed by William Herschel, whose first sighting of this star occurred 203 years ago. Succeeding generations of astronomers have marveled at the beauty of this remarkable system. From Webb's 19th century classic "Celestial Objects for Common



This photo of Lyra by Patrick McIntosh shows several of the objects mentioned in the text.

Telescopes" to our present-day "Burnham's Celestial Handbook," Epsilon Lyrae has been rightly praised as one of the heaven's finest showpieces.

Epsilon[1], the northernmost pair, consists of magnitude 5.1 and 6.0 stars, separated by 2.5". The fainter star lies almost due north of the primary. This is a slow-moving binary whose period may exceed eleven centuries. **Epsilon**[2] is also binary, with half the period of its neighbor. During Herschel's time, the 5.4 magnitude secondary was roughly south of the slightly brighter main star; orbital motion has since carried it around to the east. The current separation is 2.2". A 2.4-inch refractor, if optically and mechanically sound, will split Epsilon[1] and Epsilon[2] Lyrae on nights when the seeing is good. All four stars have A-type spectra and appear white.

Although it's certain that Epsilon[1] and Epsilon[2] Lyrae are gravitationally bound, they have demonstrated no relative motion to date. Thousands of centuries may pass before these two binaries complete their mutual orbit.

Several faint field stars near Epsilon provide interesting light tests. Small scopes should pick up a 9th magnitude field star that forms a flat triangle with Epsilon[1] and Epsilon[2]. Midway between Epsilon[1] and Epsilon[2] is a pair of 12th magnitude stars separated by about 45 seconds. This is the double star **Shj 277** — that's right, a double star located between the component stars of another double! Last June, I explained the origin of the Shj pairs. This one is optical and slowly closing. I've seen it with a 6-inch Clark refractor located on the grounds of the Oak Ridge Observatory in Harvard, Massachusetts. In Gideon Reigler's 1910 handbook "The Amateur Astronomer," both components of Shj 277 appear in a sketch of the Epsilon Lyrae system which was based on observations made with a 4-inch telescope. Webb considered Shj 277 a good test for a 3.7-inch scope, and reported that one observer had glimpsed it with a 2⅛-inch achromat! I would appreciate reports from DSM readers who observe Shj 277. Be sure to mention the aperture used.

Here's a test for eagle-eyed observers. Can you separate the wide components of Epsilon Lyrae with the naked eye? Webb wrote that William Herschel and Friedrich Bessel were both able to do the trick. At Stellafane a few years ago, some amateurs told me that they could just split the two without optical aid.

About 1.5° south of ι Lyrae, the pairs **Struve Σ 2470** and **Struve Σ 2474** form another "double-double." Not only are the magnitudes and separations of both pairs similar, but also their position angles, which differ by just 10°. There is a difference in the spectral types of the primary stars. Σ 2470 is led by a white B-type star, while the brighter component of Σ 2474 is a yellowish G-type star. They are separated by about 10' and are not physically connected.

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Variable Stars

Hints for Variable Star Observers

by David H. Levy

Variable stars are a type of celestial object well-suited to backyard observing. Some pulsate gently and regularly while others flare up unpredictably; each has an appeal all its own — and each offers the observer an opportunity to make a contribution to science. By carefully observing the changing brightnesses of variable stars, you can keep tabs on dozens or even hundreds of stars the professionals haven't time to observe — and provide valuable data that astronomers need.

While variable star observing is a specialized branch of observational astronomy, many of the basic procedures that apply to all observing also apply to variables. There are, however, some additional

methods that are particularly suited to variables.

Telescope: Each variable star has its own best combination of telescope and eyepiece, depending on where the comparison stars are in the field of view. The general rule is to use only enough light-gathering power and magnification to see the variable clearly but not so much that its magnitude is hard to estimate. Ideally, the variable should be about two magnitudes brighter than the limit of the telescope you are using. If the star is much fainter than that, you will have problems perceiving it well enough to estimate its brightness. If the variable is several magnitudes above your telescope's limit, so much light will hit your eye that its sensitivity to subtle differences in magnitude will be affected.

Mounting: Many variable star observers recommend an equatorial mount because with such a mounting, the alignment of the chart is aways the same. I don't consider this essential as I have used an altazimuth mount to do most of my variable star observing for over 15 years. (Just make sure you know which direction is north when you use a chart.)

Field of View: I still have problems with this. Occasionally, you can spend hours looking for a star field in your telescope when the problem is that you really don't know what to look for — how much of your chart does a single field of view of the telescope show? Famed variable observer Leslie Peltier used a wire ring for his charts to indicate the field of view of his telescope. Even a piece of cardboard with a hole of the proper size cut in it is a help.

Weather: Try to make your observations as consistently as possible, and the weather conditions should be the same for each session. (This isn't always possible or practical, especially if you live outside the southwest.) Otherwise, your estimates will reflect the quality of the sky as well as that of the star. Keep in mind that a cover of light cirrus clouds can have a devastating effect on the results of your observations. I have found, in fact, that cirrus clouds are worse than cumulus ones, because it's often hard to tell where they are in the sky.

Moonlight: Even if the sky is clear, a bright Moon will affect your estimates of very red variables. A little moonlight is all right for dwarf novae and some other white-colored variables, but not reddish ones.

Light Pollution: Short of moving out into the country, there is little you can do about eliminating light pollution. There is a lot you can do, however, if the bothersome light comes from a neighbor's house or from a street light. In Tucson, gentle persuasion, being friendly with neighbors, and a sympathetic light ordinance has worked wonders in removing unwanted light.

The Purkinje Effect: This effect, named for Johannes Purkinje (a 19th century physiologist), causes a red light to appear to grow brighter if it is stared at. The problem this can cause in estimating magnitudes is obvious. A very red star can actually appear to be "going nova" when all that's really happening is that your eye is over-responding to it! Some suggestions: First, use quick glances rather than prolonged stares. Second, put the star somewhat out of focus so that you see a diffuse red blob rather than a razor sharp point of light. And avoid using too much aperture. This way you don't have more red light that you really need. And finally, use averted vision.

Averted Vision: The technique of looking "out of the corner of your eye" so that the more light sensitive part of your eye can perceive faint objects is an old stand-by among those who observe deep-sky objects like galaxies and nebulae. If a star is hard to see, or if its presence is questionable, try using averted vision so that more sensitive parts of your eye can go to work. But don't try too hard unless you're willing to put up with some unpleasant side effects — if you strain your eye too much, you may have to contend with lightheadedness, dizziness, and mild nausea — effects that usually pass after you reduce the strain.

Breathing Exercises: I've been told that by taking three or four deep breaths and then holding your breath while you look through the eyepiece, you can increase your personal limit by as much as a magnitude, at least for a few seconds. The idea is that as you increase the oxygen in your brain, you will increase your visual acuity. I have tried it several times with negligible effect on my magnitude limit, but I do feel much better now, thank you. I suspect that any increase in magnitude limit is likely more than overcome by a resultant lightheadedness.

Relax!: Probably the best way to succeed in variable stars (or any other observing) is to begin in a state of anticipatory but relaxed confidence. Comfort in observing is more than a luxury. If your mounting is about to collapse, you will waste energy fooling around with it while your neighbor, who sits comfortably looking through the eyepiece of a solidly-mounted telescope, will see much more.

Altitude: The closer the variable star is to the horizon, the more it will be affected by atmospheric extinction. But should not all the stars in the field get fainter by the same amount and at the same rate? No: ground haze increases the problems with the Purkinje effect and it makes blue stars dimmer.

Dates: In recording estimates, be careful not to use the wrong date. Julian days are based on Universal Time and it is possible to record a star's estimate to the nearest minute, only to be off by 24 hours. UT is several hours ahead of the standard time zones in North America (5 for EST, 6 for CST, and so on).

Be Patient: The longer you hunt for a star, especially an easy one, the more aggravated you're going to become, and the longer you're likely to take in finding it. How long will it take you to locate the field of a star? Tell yourself it might take all night. And don't worry about it.

Organize: You'll have a much easier time if you observe like the professionals. Plan in advance what variables you want to observe, but be flexible, so that you can change your plan once you are outside.

Diversify!: Do you have more than one telescope? Then set them all up before a major observing session, and plan your program so that you will use each telescope for the stars bright enough to be accurately estimated with it. Remember that stars can be estimated most accurately when they are about two magnitudes above the instrument's limit.

Keep these guidelines in mind when you go out to observe. In the spring issue I'll present an article on how to observe them — how to use charts, data, and telescopes to get the most out of variable stars.

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Sources of Information for Variable Star Observers

Burnham's Celestial Handbook
by Robert Burnham, Jr.. Dover, New York, 1978. This work contains data on several thousand variables, and more detailed treatment of the brighter ones. A good general reference.

General Catalogue of Variable Stars
by B. V. Kukarkin, et. al.. Academy of Sciences of the USSR, Moscow, 1968. A thorough catalogue of variables containing Right Ascension and Declination, galactic coordinates, sources, types, magnitude ranges, and periods.

Variable Stars
by John S. Glasby. Constable, London, 1968. A survey of variable star types and their astrophysical nature.

Variable Stars
by W. Strohmeier. Pergamon, New York, 1972. A more up-to-date survey of variables.

DSM talks to Walter Scott Houston

It is quite possible that there would be no "Deep Sky Magazine" were it not for Walter Scott Houston. Over 36 years ago, when he began writing his "Deep Sky Wonders" column for "Sky and Telescope," most amateur astronomers were familiar with only the choicest Messier and NGC objects. Since then, he has introduced thousands of skywatchers to a celestial smorgasbord of clusters, nebulae, and galaxies. In the process, he has helped to produce today's legion of deep-sky enthusiasts, thereby creating a market for a publication like DSM.

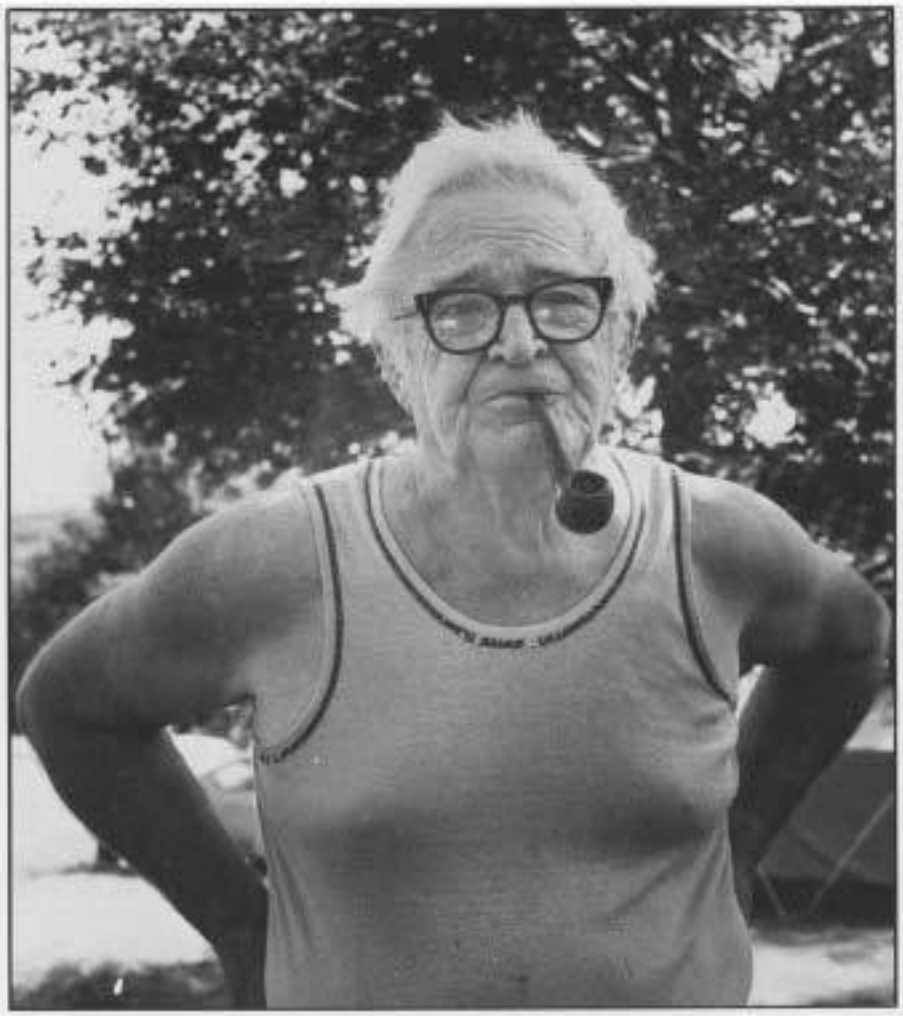
Walter Scott Houston was born in Tippecanoe, Wisconsin, on May 30, 1912. While in the fifth grade, he was browsing through a physics book owned by his father — a high-school principal — when he came across a section devoted to telescope optics. Inspired, young Walter decided to construct a telescope of his own. For an objective, he removed a non-astigmatic lens from his mother's reading glasses (he hid the frames, hoping she'd assume she'd misplaced them). This lens, coupled with a one-inch focal length eyepiece and a tube made of rolled-up newspaper, produced a nice 40x telescope. After the usual diet of terrestrial objects, Walter decided to train his telescope on the Moon. Like Galileo over three centuries before, he was amazed to discover a world pitted with craters. Thus began a life-long devotion to astronomy.

Interviewing "Scotty" Houston is no easy task, as I learned at the 1981 Stellafane convention in Springfield, Vermont. He was continually besieged by amateur astronomers seeking advice or merely wishing to say hello. I had better luck that fall at the AAVSO meeting in Waltham, Massachusetts. Here, he was in his element, surrounded by fellow members of the organization he loves so much. During a lull in activities, we sat in the back of the conference room and conducted the following interview:

DSM Your career as an amateur astronomer has spanned nearly six decades. What events during this period do you find particularly memorable?

Houston That's hard to say. I guess one occurred during World War II, when I created and wrote up the first technique for polar celestial navigation. Most of this is still the official method for the U.S. Air Force. Then, in 1958, I directed the

Richard Berry



Manhattan Moonwatch Station which made the first world sighting of Explorer 1 — the first American satellite. We caught it one full orbit before two other American stations. I guess these are among my most memorable experiences.

DSM What individual or individuals would you say influenced you the most in amateur astronomy?

Houston Joseph Meeks, for one. He was the one who got me interested in variable stars and persuaded me to join the AAVSO while I was a student at the University of Wisconsin. You know, variable stars and the AAVSO are my number one love in astronomy.

DSM Of course, one of your biggest claims to fame is the deep-sky column you write for "Sky and Telescope." What are some of your favorite sky objects?

Houston Oh, they change from decade to decade. My all-time favorite is NGC 5128. Harlow Shapley was so amused, he sent me, in 1932, an autographed 8x10" print of this galaxy, taken with the Harvard 60-inch telescope. I've always liked objects that offer some kind of challenge. That's why my current favorite is the California Nebula in Perseus.

DSM Let's say that you could only observe with one telescope. Of all the telescopes you've used over the years, which one would it be?

Houston One I currently own, a 4-inch f/15 Clark refractor that was once owned by William Tyler Olcott.

DSM Continuing this line of thinking, if you had to choose one area from which to conduct all of your skywatching, where would it be?

Houston Well, the United States is pretty well shot by light pollution. Back in 1935, I could count eighteen stars in the Pleiades from downtown Tucson. Recently I saw just five. Conditions are much better in Mexico and Central America, and I hope to find a good site down there.

Scotty's astronomy-related achievements are numerous. Before leaving grammar school, he had managed to observe all of the recognized Messier objects (103, then) with his home-built telescope. In 1931, while a student of English student at the University of Wisconsin, he joined the American Association of Variable Star Observers (AAVSO) and ultimately forwarded 15,000 variable star estimates (and served three times on its council). He has ground about two dozen telescope mirrors and invented the wedge photometer. He has helped to found several astronomy clubs, and is an honorary lifelong member of several others. In 1956, he found his first meteorite, and has since uncovered more than a dozen others. Not limiting himself to optical astronomy, Scotty has electronically detected over 100 solar flares, recorded meteors by electronic scatter reflection, made a radio map of the sky at 108MHz, and has located two dozen radio sources with a radio telescope. Besides his acclaimed "Deep Sky Wonders" column in "Sky and Telescope," he has published articles in a number of astronomy and science magazines, including DSM.

DSM Here's a question that appeared in a newsletter of a San Francisco astronomy club: If you could use the 200-inch Hale telescope on Palomar Mountain to view just one object, what would it be?

Houston The 200-inch has a lousy figure; its images aren't very sharp. I suppose I'd try the Orion Nebula, although the field of view of the 200-inch might not be big enough. I guess Pluto would be a better choice.

DSM Amateur astronomy has seen amazing change and growth in recent years. Do you see any negative aspects of amateur astronomy today?

Houston There seems to be a tendency of some amateur astronomers to get involved with groups where intellectual curiosity is replaced by social posturing. Such people become concerned with their status within the organization, and lose sight of the true meaning of amateur astronomy.

DSM What do you see as the most positive aspect of amateur astronomy today?

Houston There is still a segment devoted to public service, rather than social infighting and competition. There have been great strides in astrophotography, although some astrophotographers get carried away and waste a lot of time. Nova patrols are an exception here. If I were starting all over in astronomy, I wouldn't be an astrophotographer at all.

DSM Considering your many years of experience as an amateur astronomer, it's only natural that anyone interested in sky observing would seek out your advice. What do you say to the newcomer just getting started in astronomy?

Houston Try dabbling in every aspect of amateur astronomy. Don't get bogged down in one particular area too soon.

DSM Do you have any advice for the experienced telescope user?

Houston Just remember that a hobby is cheaper than a psychiatrist. Experienced observers don't need much advice. By the time an observer becomes "experienced," he knows what to do.

Walter Scott Houston's contributions to amateur astronomy have not gone unnoticed. He has received the Astronomical League Award, the Bruce Blair gold medal, the Amateur Astronomers Association of New York silver medal, and an award from the Northeast Region of the Astronomical League. Though he may scoff at the suggestion that he is a "living legend," he is, nevertheless, a center of attraction whenever he appears at an astronomy convention.

Those who associate Walter Scott Houston with amateur astronomy are often surprised to learn of his exploits in other areas. During World War II, he was the senior celestial navigation instructor at the Army Air Force Advanced Navigation School in Selma, Alabama. After the war, he taught English literature at Kansas State and Wesleyan Universities. As senior science editor with Xerox Education Publications, he conducted the first national acid rain survey, the results of which led to today's intensive effort by many research teams to determine the causes and cures for this pollution problem. In recent years, Walter has become active in committees dedicated to addressing the problems of the elderly. To say that he is a versatile individual is certainly an understatement!

DSM What future projects does Walter Scott Houston have in mind?

Houston I'm completing an index of objects featured in my "Deep Sky Wonders" column. It'll be available at cost. I'm also building an observatory. The design will be different, so my readers won't be disappointed.

DSM If you could start your career in amateur astronomy all over again, would you chart a different course than the one you took?

Houston No, not really, except that I would have started variable star observing earlier.

As we completed our interview, there was an announcement naming the newly-elected members of the AAVSO council. Among those voted in by the membership — Walter Scott Houston. It was a fitting gesture to this veteran observer who was celebrating his 50th year in the AAVSO. We can all thank him for taking us a little deeper out into the skies.

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Variable Star Observers Gather in Tucson

Have you ever been to an amateur astronomy convention? These days, you can find one that caters to almost every possible interest: telescope making, deep-sky observing, lunar and planetary work, photoelectric photometry, or occultation timing. Amateurs are looking for a challenge. Many feel that turning a telescope to the stars is a joy that can be augmented if the results of their observing have scientific value in addition to intellectual enjoyment. This was the case at the 70th spring meeting of the American Association of Variable Star Observers (AAVSO) which was held last April in Tucson. Participants quickly learned that their work is needed more than ever by professional astronomers working in the field.

During five days of conferences, tours, lectures, and informal conversation, the theme of professional interest in AAVSO work kept resurfacing. This was, perhaps, the greatest advantage of holding the event in Tucson, a city girdled by telescope topped mountains. "AAVSO tour?" asked a startled observer at Mount Hopkins, "I'll join it. I might learn something!"

The event produced an array of new thoughts. Since April weather normally whets the appetites of recently snowed-in observers, the meeting was designed to take full advantage of outside activities. The three days preceding Saturday's paper session were crowded with tours of both Kitt Peak and the Multiple Mirror Telescope; so many delegates signed up for the tours that they had to be spread out over three days, resulting in a personalized schedule for each member. Rik Hill took charge of a hands-on telescope visit at Kitt Peak at which participants could watch instruments such as the Burrell Schmidt slew back and forth and do other neat tricks. Meanwhile, Dan Brocious of the Smithsonian Astrophysical Observatory staff opened what is often called the "multiple-multiple telescope" to the visitors.

The astronomical and optical facilities at the University of Arizona are among the most extensive in the world. Walking tours conducted by Delores Hill included sights such as the massive mirror grinding facilities at the Optical Science Center and the Lunar and Planetary Lab. And there also was the behind-the-scenes look at the inner operations of the Flandrau Planetarium.

This AAVSO meeting was marked by two unusual events. On Wednesday evening members attended a special show at the Flandrau, in honor of both the 70th anniversary of the AAVSO and the spirit of amateur observing. Two nights later, 70 people arrived at Jarnac Observatory for several hours of variable star observing under a moonless desert sky. Making themselves at home, delegates appropriated observatory telescopes and binoculars and the warm night air buzzed to the thrill of active observers watching their favorite stars.

For the first time the AAVSO featured a "star-bowl" competition, during which two teams of would-be trivia experts responded to questions about telescopes, variable stars, and astronomical history.

The weather was not the only element that cooperated. Astronomers from the University of Arizona's Steward Observatory helped to ensure the success of the meeting in several ways. On Tuesday evening, James Liebert emphasized the continuing and pressing need for more data on several types of cataclysmic stars. Addressing a topic that seems to have become traditional at recent meetings, Liebert's presentation categorized the different types of behavior that characterize cataclysmic stellar events. Rising enthusiasm for all stages of stellar evolution set the tone for the talk that followed. Catherine Imhoff's presentation considered stars at the other end of the development sequence, the T Tauri stars. Asking "Why is it that stars don't grow up; they grow down?", Dr. Imhoff concentrated on the T Tauri stars that are extremely difficult to visually observe. However, her proposed photographic program might attract the interest of some of the more daring variable star observers. These talks were well complemented by Saturday's banquet address by Roger Angel, which outlined the future of ground-based telescopes. Angel heads a team whose project of casting large, lightweight pyrex mirrors has already produced some successful chunks of glass.

These professional talks were balanced by 16 short seminars given during Saturday's paper session and, curiously, they seemingly fell into natural divisions of eclipsing variables, symbiotic stars, observing techniques and aids, astronomical history, and solar activity. With this diversity, there was surely something for everyone.

Style also differed greatly. Lee Anne Willson outlined recent results of a newly uncovered 1978 eclipse of R Aquarii as a detective's puzzle whose pieces were dramatically tied together by Peter Garnovich and Janet Mattei. Kenneth Wilson offered a solution to the longstanding AAVSO problem of ensuring accuracy in Julian Date and decimal; his method was to record data using local days and times, and letting a home computer convert this to Julian Dates. Barbara Welther of the Harvard-Smithsonian Center for Astrophysics offered a sensitive look at veteran astronomer and AAVSO'er Henrietta Swope, who died in 1980.

Even Saturday morning's business meeting offered a surprise. After years of using a standard AAVSO report form, Director Janet Mattei announced that the means of reporting would be altered to increase accuracy and standardize observations.

All participants in this year's spring meeting left with a great sense of pride. As each day blossomed, the differences between amateur and professional skywatchers faded. As I met more and more people, they were no longer the three-digit code used on their observing forms; they were thinking, learning, laughing, warm people. And they were encouraged that the importance of their observations was on a rapid upward swing in its light curve.

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DSM Reviews

Sky Catalogue 2000.0, Volume 1: Stars to Magnitude 8.0
Edited by Alan Hirshfeld and Roger W. Sinnott
Sky Publishing Corporation and Cambridge University Press, 1982
xxvi+604 pages; cloth $44.95, paper $34.95
(Paper edition available from DSM for $31.95 postpaid.)

I picked up my trusty old "Atlas of the Heavens Catalogue" and threw it away! After reading the introduction to the "Sky Catalogue 2000.0," I could find no reason to keep the old catalogue, as this new work is such an improvement and so much more thorough than the old.

If you have any desire to know the positions, magnitudes, colors, spectral types and so on about individual stars, do not hesitate to get this volume. The information it contains simply cannot be found without scrutinizing a dozen or more separate references. It would be easy to go on singing the praises of this work, but the conclusion would be the same: What a book!

I definitely should have sprung for the hardbound edition!

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Standards for Reporting Local Sky Conditions

The vast majority of deep-sky objects are small and faint, and are difficult to view in any telescope. Since owners of large aperture telescopes are likely to spend a significant part of their observing time hunting down objects at the very limits of detection, I feel that it is important to discuss how we should go about reporting the results of our observations so that others can benefit from them.

To be useful, an observing report must contain enough information for another person to make an accurate judgement about the appearance and visibility of the object described. Every observing situation is unique, with its own blend of light pollution, weather conditions, telescope and observer characteristics. Unfortunately, all too many observing reports describe the local conditions in terms such as: "weather clear, telescope 8-inch, galaxy faint." What does this mean to me when I read it? Is clear weather in Peoria the same as clear weather in Boston? Does an 8-inch RFT Newtonian give the same visual results as an 8-inch Clark refractor? How faint is faint? In this and future articles I will attempt to define my own standards for observation reporting, using actual examples. I hope that my comments will prompt other observers to think about and describe their standards, with the goal of developing a concensus.

I believe that local sky conditions, more than any other factor, influence the results and repeatability of deep-sky observations. To an observer reading your report, what is important is not so much a description of what the sky looked like, but how it affected the visibility of faint objects. Statements like "First Quarter Moon 30° above horizon" or "thin, broken clouds" are useless. A First Quarter Moon in a very transparent, dry desert sky has a very different effect on observing than the same First Quarter Moon seen from Nantucket Island at sea level in a humid sky. Instead, what I need to know to understand your report can be summarized by three factors: limiting visual magnitude, sky contrast, and "seeing."

Limiting visual magnitude is a simple measure of the sky's absolute transparency. Fortunately, you can measure it accurately (for your eyes) and report it simply by noting the magnitudes of the faintest stars you can see with your unaided eye near the objects you are observing. Virtually every constellation has several stars with magnitudes between four and seven located in easy-to-remember places, so it is merely a matter of looking up the magnitudes and either memorizing them or writing them down. In the summer sky, the neck of the "Swan" in Cygnus presents a nice, calibrated sequence of stars plus a fine Long Period Variable (χ Cygni). Other easy-to-remember areas are Orion's belt, the "Little Dipper," and the tail of Scorpius. You will find the "AAVSO Variable Star Atlas" invaluable for looking up magnitudes.

Sky contrast is more subtle but also more important. Light pollution makes deep-sky observing difficult not by limiting the visibility of faint stars (as is commonly believed), but by reducing sky contrast, hence limiting the visibility of faint extended objects. By shielding my eyes from street lights, I can often see stars of magnitude 5.5 from downtown Boston. But while the light pollution has reduced my limiting stellar magnitude only about 0.5, it totally destroys my ability to see faint galaxies or planetaries. These objects require high sky contrast, which doesn't exist near cities.

I quantify the local sky contrast at a given location by using the following simple scale of 1 to 5:

Level 1: **Severe light pollution, haze, or moonlight.** The sky is very bright to the naked eye and in the telescope. There is no trace of the Milky Way, or objects like M31, the Beehive Cluster, or the Lagoon Nebula.

Level 2: **Poor sky contrast.** The Milky Way is barely visible but shows no detail. M31 and the Double Cluster in

Seeing conditions affect success in observing and photographing deep-sky objects. The Horsehead Nebula photo at left was made by David Healy, who used a 300mm lens and a #92 filter, exposing for 20 minutes on 103aE. The one at right was taken by Ron Potter, with an 8-inch Schmidt Camera and a 15 minute exposure on hypered TP 2415.

Perseus may also be barely visible to the naked eye. Other faint, extended objects are wiped out.

Level 3: **Good sky contrast.** The Milky Way is immediately noticeable but is not very detailed. M31, M44, M8, and some other extended objects are fairly easy to detect.

Level 4: **Excellent sky contrast.** The sky appears very dark and the Milky Way is bright with many rifts, knots, and details visible. All of the brightest extended objects are easy to see: M31, the Double Cluster, M44, Omega Centauri, etc.

Level 5: **Superb sky contrast.** The sky appears black, with an overwhelming number of stars visible. Even extremely faint extended objects such as M13, M6, and M22 are visible. These skies are usually found in the American Southwest.

Seeing is the third factor that influences the visibility of deep-sky objects. Bad seeing, in the form of atmospheric turbulence, severely degrades the amount of detail that can be seen in extended objects. The types of objects that are most affected by poor seeing are: stellar planetaries, the central stars in large planetaries, faint globular clusters, and some of the detail in large galaxies.

Seeing can be difficult to quantify in that the aperture, optical quality and thermal stability of the telescope all play a part. When I am sure that my telescope has finished cooling off, I try to measure seeing by looking at a few close double stars. Generally, I can tell if the seeing disk or average star blur due to turbulence is several seconds of arc in diameter (poor), about one arc-second (good), or better than one arc-second (excellent and rare).

Taking the time to assess your local observing conditions pays dividends other than simply improving your observing reports. You will soon become aware of just how much of what you see depends on a number of variables that are constantly changing. You will appreciate the subtle interaction of your eyes, brain, telescope, and the sky. And best of all, you may find yourself, as I did, learning to recognize faint constellations, variable stars, and little-known doubles.

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DSM Reviews

A Revised Shapley-Ames Catalog of Bright Galaxies
by Allan Sandage and G.A. Tammann
Carnegie Institution of Washington
Publication 635, 1981
157 pages, cloth $31.00

In 1932 the Harvard astronomers Shapley and Ames published a survey of bright galaxies, attempting to include all objects brighter than photographic magnitude 13.2. Their catalogue, based on fresh plate material from the Harvard Observatory Sky Patrol cameras in both hemispheres, yielded a fairly homogeneous sample of nearby galaxies. Over the years the galaxies on this list have become the most frequently studied objects of research in cosmology, galactic morphology, stellar content, and evolution. Amateur astronomers are familiar with the catalogue as the galaxy list contained in the "Atlas of the Heavens" catalogue.

The recent explosion in our knowledge of galaxies has shown that though the objects of the original list are interesting ones, much of the data about them are incorrect or biased. For example, at that early date, the magnitude system was not standardized, and the patrol plates did not record many objects of low surface brightness. It is also now known that the catalogue is not complete to magnitude 13.2, and becomes only 50% complete by magnitude 12.7. Further, at the small scale of the plates, morphological types were often mistaken: a small edge-on spiral would be classed as E6 (an elongated elliptical).

Since then, basic data for bright galaxies have been gathered for most objects. Large-scale telescopic photographs have been used to determine type, and redshifts from spectra now exist for thousands of objects. Hundreds of galaxies have been thoroughly observed in detail in all regions of the electromagnetic spectrum. Photoelectric photometry has allowed a standardized system of magnitudes to be established.

NGC 253 Thomas L. Dessert

Thus the time is ripe for this work, a welcome addition to reference works for both professional and amateur astronomers. The catalogue itself contains 1246 entries, the same number as the original, but a few objects have been dropped and replaced by others. The data for each entry are arranged on a double page with 21 columns. NGC and alternate designations are listed along with high-precision coordinates in three systems (Right Ascension and Declination, galactic, and supergalactic), Hubble types (newly determined by A. Sandage), integrated B (blue) magnitudes and colors, angular dimensions, and more. We can now reasonably ignore the old "Atlas Catalogue" galaxy section, and rely on this new data.

Perhaps the most valuable part of this volume is an appendix containing first-class photographs of 90 objects, six of each Hubble type. Presented in a format similar to "Hubble's Atlas of Galaxies," these negative reproductions have been made from the plate files of the 5-meter Palomar and the 2.5-meter Mt. Wilson scopes and from exquisite plates from the recently completed 2.5-meter DuPont telescope at Las Campanas in Chile.

Further appendices give lists of galaxies by Hubble type, charts showing some statistical properties of the catalogue, an additional list of 822 galaxies brighter than magnitude 13.4 (that properly should have been in the original list), and a bibliography of the hundreds of references cited in the text.

It might be mentioned that the writing in the book is a little spare, much like that in a formal research paper, so there are few wasted words. This may present some difficulties for those without much astronomical background when explanations are terse. The text is straightforward, however — there are no "hairy" equations — and should present no problems for amateurs wanting information on specific objects.

For many amateur observers this book will satisfy the needs of galaxy observation better (and more cheaply) than any other single work. Along with data for more than 2000 galaxies, the accompanying array of photos balances the blocks of numbers in a way that will provide utility and aesthetic enjoyment for many years.

Brian Skiff
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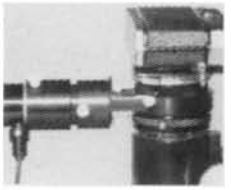

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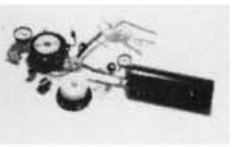

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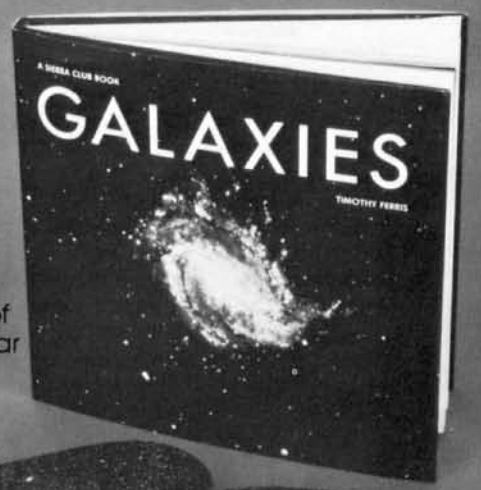

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How to Give a Slide Show

by Dick Suiter

When I first started thinking about this article, I considered calling it "How to Give an Astrophoto Slide Show," but I quickly realized that what I am going to say applies to ALL slide shows. The rules are simple, but it is surprising how few people know them. It has become a standing joke that slide shows are always boring. Nothing is supposed to drive off pesky guests faster than saying, "Let's look at the slides I took on our summer vacation."

Some people think that good slide shows are characterized by slick title slides, accompanying music, or expensive dual projector fade/dissolving technology. While such touches are nice, they don't strike at the heart of what is wrong with most slide shows: they are too long. This problem could be cured with two simple rules:

1) Don't show more than 40 slides.
2) Don't take more than 20 minutes.

If every "slide-bore" were to stop right here, and follow just these two rules, their shows would be immensely improved. Let's face it: there's an upper limit to the attention span of even the politest adult. This limitation forces you to edit severely. I have come across people who chose the Bell and Howell projector because the little cubes hold almost exactly one roll's slides. They throw everything in, including the slide at the end of the roll with only a half picture on it. Imagine what sitting through 4 or 5 of these little cubes is like! Few people edit enough. Good photographers claim that fewer than half of the pictures they take are worth showing. Excellent photographers say they are lucky if they get two or three per roll worth keeping. Remember: less is more.

Keep in mind that technical perfection is not enough. Each slide has got to be well composed and show what you want to show and it's got to be different enough from other slides to justify showing it at all. Some more rules:

3) Don't be repetitive. Pick out the best slide you took of a certain type or subject, and show it alone.

4) Arrange the slide show around a coherent theme or thread of thought. Don't jump around.

5) Don't store your slides in trays. This is a temptation to break rule #1.

6) Re-edit for every show, and keep your audience in mind. Your astronomy club probably wants to see all of the astrophotos you took during the 12,000-mile trek during which you lugged a 16-inch up the north face of Mt. Everest and used it to photograph planetary nebulae in NGC 253 in hydrogen-alpha light. Your club probably can laugh with you as you describe how the fifty-below temperatures gave you trouble by freezing your oxygen mask to the guiding eyepiece. But your Aunt Maude doesn't care. She wants to see the photos you snapped in Hawaii, and loathes pictures of the sky.

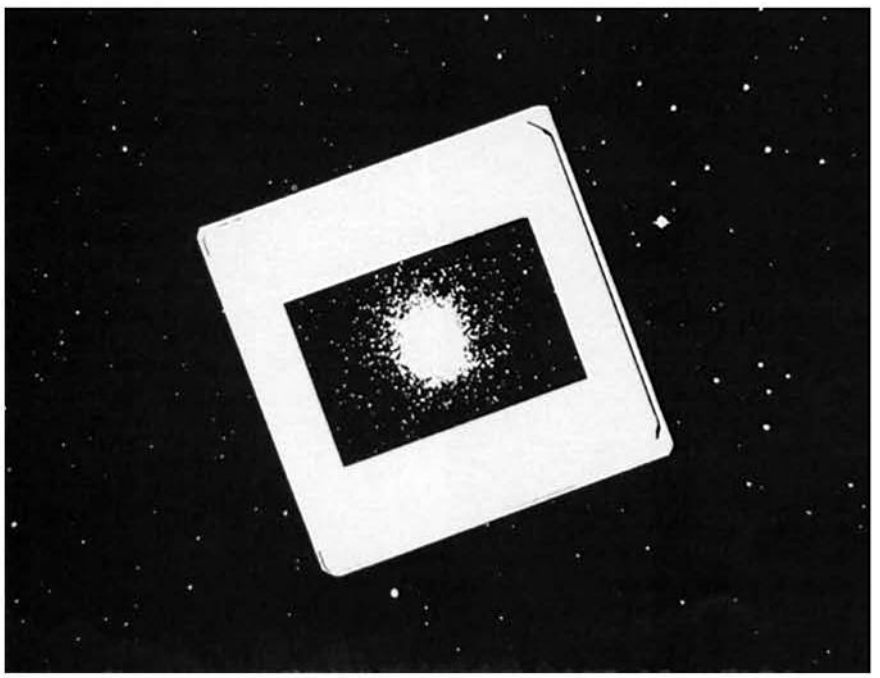
If you ever hear yourself saying some of the following, you're including too much:

"Here's the same thing from another angle."

"I took this one because I wasn't sure the other one would come out."

"Here it is again."

To generate a coherent slide show, you have to see them all together so you can arrange them. They sell little light-table viewers that are excellent for this, and if you are a cheap-skate, you could probably make one yourself.



Lee C. Coombs

Sometimes the correct order for slides is not chronological, but a thematic arrangement passing from subject to subject. The most boring thing in the world is to listen to a linear narration — "First we went here, and then we went there, and. . . ."

Some more rules:

7) Start with a really good slide — an eye-catcher. The worst is people standing around in the airport, followed closely by a shot out at the airplane wing. A slide that sums up the show is the best.

8) Avoid describing technical details of the photography unless it's what your audience wants. Most people don't understand photographic techniques and couldn't care less anyway. If your photo is a technical masterpiece, the savvy people in your audience will know it without being told. Naturally, if your show is about hypersensitizing TP 2415, you'd better have all the gory details.

9) Don't show too many shots of you and your friends standing around in front of the scenery. While it's okay to take these slides as personal keepsakes, don't inflict more than one or two on your audiences. An astronomy club that shall remain nameless put together a slide show after the 1979 solar eclipse and showed it at various conventions around the midwest. They filled at least two 140-slide trays (breaking Rule #1), out of which at least 100 slides consisted of themselves grinning in motel rooms. The result was devastating. Only CPR saved some of the people who saw that show!

10) After you have made the show as short as you think possible, go through it and eliminate a few more slides just to prove how ruthless you are (growl!). There are always a few clinkers left that are there, not because they are good but because you have some irrational attachment to them.

For non-astronomer audiences, you need to be educationally oriented. These people don't know what they are seeing in the pictures, so you have to be ready with stuff like "This photograph covers an area of the sky about as big as your thumbnail at the end of your outstretched arm," or "The cluster of stars at the center is 10,000 light-years away and contains 100,000 stars like the Sun." Be ready to field questions like, "How far is a light-year?" and the usual follow-up question, "How far can you see with your telescope?" Show only a few astronomical slides in a row, interspersing with pictures of the instrument, etc. The attention span of an audience not familiar with the subject is minuscule.

Al Lige

Martin C. Germano

Larry Kadooka

When showing slides to other amateur astronomers, you are speaking to a friendly audience that knows what is is being shown and is interested in it, but even so the rules of general slide shows still apply. I once saw a guy who was describing a clock drive he had built, and he gave an interesting talk. But during the slide presentation, he showed every slide ever taken with that drive, all of which were greened-out by skyglow. He only recognized the subject in about half the photographs, and after 10 minutes of this, even a friendly audience was turning ugly.

Know all of the technical details, and be prepared to give them — if asked. Films, exposure, special techniques, f/stop, and development — all are important, but don't offer it gratis.

Watch out for projection scale effects. Astrophotos are strange beasts, mainly because of dark sky and low contrast objects. A slide that looks good projected on a foot-square screen or in a viewer may not look so good full size (or it may look better). Check out which slides you want to present by projecting them ahead of time under the actual showing conditions.

Before showing nearly any astroslide, try copying it — the increased contrast helps a lot.

Follow the very dark astrophotos with a dark slide to indicate the end of the show and to prevent "snow blindness."

If you follow these rules (and even break them when appropriate), you will discover that people will enjoy your shows and will cease playing sick to avoid them. You'll know you're doing it right when your shows leave your audience wanting just a few more slides and visibly disappointed that the show is over.

Remember, when you ask people to look at your slides, they are doing you a favor if they agree. It's your responsibility to surprise them with some real entertainment.

One last note: once you have put together a nice tight little show and you know it is good, don't be perturbed by someone in the audience who comes up afterward and tells you how he would have done it. He's the sort of guy who'd give a slide show that would consist of 400 pictures of his wife and kid standing in front of the gas station restrooms he stopped at during his last vacation, with the lame excuse, "It was the only time I wasn't driving."

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Scanning the Literature

A vast amount of astronomical literature is published every year. So much material is produced that astronomers must rely on publications such as **Astronomy and Astrophysics Abstracts** (containing short summaries of each published paper or book) to find everything published on a particular subject of research.

Though most papers have little interest for amateurs, sometimes one will contain information potentially useful to observers with modest instruments. Our purpose here is to list and briefly describe some interesting work that has recently appeared. This is not a "news report" recounting the latest discoveries, but an attempt to sift through the mass of titles to find something DSM readers might use for the visual observation of deep-sky objects. For the first installment, the list will be restricted to the three principal American journals: **The Astrophysical Journal (ApJ), The Astronomical Journal (AJ),** both published by the American Astronomical Society, and **Publications** of the Astronomical Society of the Pacific (**PASP**).

ApJ is principally a theoretical journal dealing with cosmology, stellar structure and evolution, and work outside the visual region of the electromagnetic spectrum (e.g., X-ray satellite observations, radio interferometry). Sometimes the papers here are so abstruse that even some researchers cannot understand the mind-boggling titles. **AJ** and **PASP** are much more easily read, both being journals of observational work, and frequently have articles of interest to experienced amateurs.

The three journals are the most commonly found in college and metropolitan public libraries. Almost any professional observatory will have them and may be willing to let you use them on the premises. The papers cited below were published during the first six months of 1981, and were available by early August 1981.

McClure, R.D., Twarog, Bruce A., Forrester, William R., "The Old Open Cluster NGC 2506 and its Similarity to NGC 2420." **ApJ,** v. 243, p. 841, 1981 (1 February). Magnitudes for about 700 stars in the cluster are given. At a derived distance of about 3 kiloparsecs, the observers found that about 50 members are brighter than B (blue) magnitude 15.0, and about 150 members are brighter than B 16.0. The paper includes a photographic identification chart so that individual stars may be identified at the telescope.

Strom, S.E., Forte, J.C., Harris, W.E., Strom, K.M., Wells, D.C., Smith, Malcolm G., "The Halo Globular Clusters of the Giant Elliptical Galaxy Messier 87." **ApJ,** v. 245, p. 416, 1981 (15 April). Photographers of M87 may wish to check this paper, which gives U (ultraviolet), B and R (red) magnitudes for about 1700 objects around the galaxy. Their statistical analysis indicates that about 70% of the objects are globular clusters involved with the galaxy. Can any of these be photographed with an amateur instrument?

Christian, C.A., "King 8: A Metal-Poor Disk Cluster." **ApJ,** v. 246, p. 827, 1981 (15 June). King 8 is a faint open cluster in Auriga, whose brightest stars are about magnitude 14. UBV measures of 180 stars are given, with an identification chart showing the location of each.

Abt, Helmut A., "Visual Multiples. VII. MK Classifications." **ApJ Supplement Series** v. 45, p. 437, 1981 (1 March). The ApJ Supplements contain papers which are comprised mainly of tabular material, or long lists of computer printout. This paper will be of interest to double star observers. Accurate spectral types for 865 components of pairs are given, enabling a better determination of their true colors.

van den Bergh, Sidney, Hesser, James E., Harris, Gretchen L.H., "Observations of the Brightest Globular Clusters Associated with NGC 5128." **AJ,** v. 86, p. 24, 1981 (January). Globular clusters were discovered in this strange elliptical galaxy only in 1980. This paper discusses all seven such known objects. An excellent blue light photograph is included in this paper.

Miller, H. Richard, "Photoelectric Comparison Sequences in the Fields of Five Seyfert Galaxies." **AJ,** v. 86, p. 87, 1981 (January). Seyfert galaxies often have nuclei which vary in brightness over a period of months. To help with calibrating measurements, this paper gives magnitudes for several stars in the vicinity of five Seyfert objects. Each field has at least one bright star, and several within the reach of an 8-inch or 10-inch telescope. The galaxies themselves have V magnitudes in the 11-14 range.

Schmidt, Edward G., "uvbyHβ Photometry of the Galactic Cluster NGC 7790." **AJ,** v. 86, p. 344, 1981 (March). Visual magnitudes for 16 stars brighter than magnitude 14 are given here.

Burkhead, Martin S., Hutter, Donald J., "A Photometric Study of NGC 3623, NGC 3627, and NGC 3628." **AJ,** v. 86, p. 523, 1981 (April). Messier observers will recognize the NGC designations for M65 and M66, and their bright companion NGC 3628. V magnitudes for several bright stars around the group are listed here.

Stetson, Peter B., "A Photometric Study of the X-ray Globular cluster NGC 1851." **AJ,** v. 86, p. 687, 1981 (May). Magnitudes for hundreds of cluster stars and bright field stars are given in this excellent paper. Included are photographs of this seldom-viewed yet bright cluster in Columba.

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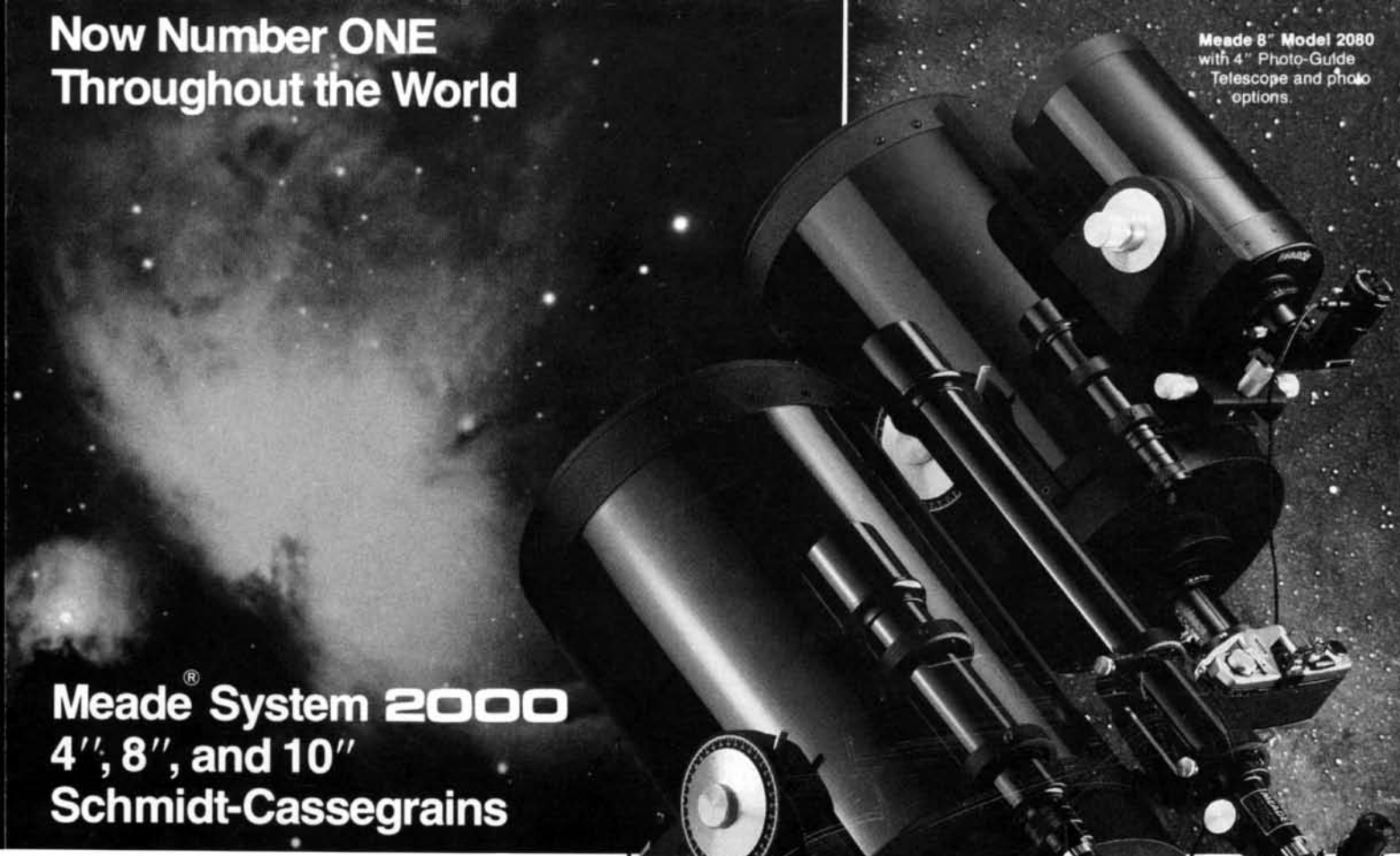

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Background photos: (left) The Orion Nebula; Meade 2080, by Leo Henzl. (right) The Milky Way in Sagittarius; piggyback Model 2080 photo by Emery Hildebrand.

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